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ENGINEERING JOURNAL.

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NEW YORK, MARCH, 1890.

How rapidly the older generation of engineers is passing away, we are reminded by the death of Mr. William J. McAlpine, following a few weeks after that of Horatio Allen. They were nearly the same age; both had their share alike in the beginning of the great public works in this country and in their later development, and to both the present generation is deeply indebted, for they were among those who may be said to have created the science of engineering in America.

On another page will be found the first of a series of plates showing Howe truss bridges of different lengths. This will include bridges from 30 ft. up to 150 ft. span, and each plate will be accompanied by complete bills of material both for the timber and the iron work. The intention is to make these plates and the accompanying bills of material so complete that no further instructions will be needed, and they can be used at once as working drawings. The designs have been made by an acknowledged expert, the strains carefully calculated, and all the details worked out in very complete fashion.

Strange as it may appear, there is no series of this kind in existence, or at least accessible to engineers generally; and it is believed that these plans will be of great service to engineers who are called upon to build wooden bridges —and there are very few who are not required to do so at some time or other. It will be many years yet before wood is entirely displaced as a bridge material, and probably there is no railroad engineer now living who will not have in his charge at some time wooden bridges; while for highway work their use will continue as long as timber is reasonably cheap and abundant in this country —and that is a term to which no one will venture yet to place a limit.

The Baldwin Locomotive Works are just completing 15 engines which are among the heaviest in the country. They are of the 10-wheel pattern, with three pairs of driving-wheels coupled and a four-wheeled truck. The cylinders of these engines are 20 in. in diameter and 24 in. stroke; the driving-wheels are 5 ft. in diameter. The boilers are 64 in. diameter of barrel, have Wootten fire-boxes and plain (not extended) smoke-boxes. These engines are for the Philadelphia & Reading Railroad, and are intended to run fast freight trains, but will very probably be used also for heavy passenger service when needed.

The College of Civil Engineering of Cornell University purposes collecting in a concise and practical form for use or reference facts bearing on the pollution of drinking waters. Engineers everywhere are asked to co-operate, and will, no doubt, readily extend their aid. Samples of water sent will be submitted to thorough analysis, and notes or reports made on this subject will be carefully filed and used. Due credit will be given to all persons contributing, and the results obtained will be published for the benefit of the profession. Engineers desiring to give their aid may communicate with Professor E. A. Fuertes, Director.

In this connection it may be noted that the College is well equipped with laboratories for research into engineering problems, tests of material, etc., and is always ready to give its aid to such investigations.

Some remarkable things have been told of the Spanish submarine torpedo boat, the *Peral*, and these seem to be confirmed if correct reports are given of tests recently made at Cadiz. From these accounts it appears that the speed of the boat while running on the surface was about eight knots an hour, while under water she ran between five and six knots an hour. The boat was navigated for over three hours with all connection with the outer air completely shut off, and for more than two hours in fighting trim, with only 4 in. of the observation turret above water. One continuous trip of 40 minutes was made with the boat entirely under the water, during which time she traveled about four miles. The machinery is said to have worked without the slightest trouble, and during the submarine trips the crew did not experience any inconvenience whatever.

The 110-ton guns built for the British Navy have not done very well so far, several of them having proved defective. Meantime much opposition is manifest among experts to the construction of any more of these guns. It is pointed out that for the cost of one of these guns a number of smaller ones could be constructed, which in all probability would be more effective in actual service. Moreover, the cost of firing these guns is so great—each shot requiring an expenditure of nearly $1,000—that it will be difficult to practise with them, or, indeed, to give them a proper test for their efficiency. Italy and England are the only nations which have adopted these huge guns. France has not gone beyond 74 tons in the weight of her largest cannon, and no other country has exceeded 50 tons. From present indications, it is doubtful whether the number of those built in England will be much increased.

The total tonnage of new vessels set afloat on the Lakes this year, not including tug-boats and such small vessels, was close upon 94,000 tons, which, although somewhat less than was reported for 1888, shows great activity in shipbuilding. The tonnage of the present season, moreover, includes a much larger number of steamers than in 1888, when the report was swelled by a number of schooners

and barges of large carrying capacity. The list for this season includes 98 steamers, having a total tonnage of 80,138 tons, and 23 schooners and barges of a total of 13,743 tons. The largest steamer on the list was of 2,670 tons measurement. More of these vessels than ever before were of steel or iron, and the steamers generally were supplied with engines of the latest and most economical pattern.

A GENERAL rural and forest exposition will be held in Vienna, Austria, in 1890, beginning May 15 and lasting until the end of October. The exposition is intended, in the first place, to show the progress of agriculture and forestry in Austria; but in several of the groups it is intended to make it an international exposition, in which all countries will be invited to take part. The exposition will include products of agriculture and forestry; live stock; agricultural machinery; plans for drainage; methods of husbandry, and designs for all sorts of constructions affecting rural and forest work. The articles which foreign exhibitors are specially requested to send are agricultural tools and machinery of all sorts. The Secretary of the General Committee is Herr A. Hochegger, who may be addressed at Vienna.

THE Government of New South Wales is trying to secure the establishment of locomotive works in that Colony, and offers to give an order for 100 locomotives to any builder who will locate himself there, and will erect suitable shops, furnished with modern tools and appliances. The building of the 100 engines may extend over three years.

All or nearly all of the railroads in New South Wales belong to the Government, and there were last year 431 locomotives employed upon them. It would seem as if the large capital required for well-equipped locomotive shops could hardly be safely invested unless there was a strong probability that orders could be secured from the other Australian colonies.

THE Railroad Commissioners of New Zealand in their last report, which covered the year ending March 31, 1889, state that there are now 1,777 miles of Government railroads in operation. This includes nearly all the railroads in the Colony, the only private lines being a few short branches connecting with coal mines, etc., and one short road in the Middle Island. The Government roads, we believe, are all of 3 ft. 6 in. gauge.

The total earnings of these lines for the year were $4,828,257; the expenses (64.8 per cent.) were $3,131,698, leaving a net return of $1,696,759. This does not indicate by any means a heavy traffic, as the gross earnings were only $2,706 and the net earnings $955 per mile worked; but it is probably as much as could be expected from a system which necessarily includes a good many miles of unproductive lines.

The total capital invested in the Government lines amounts to $65,208,500, which is about $36,700 per mile—not a very high cost when we consider that there are in the system some very expensive mountain lines, including several sections where it has been found necessary to use the rack-rail. The net earnings last year were 2.6 per cent. on the capital invested, an improvement over the previous year, when only 2.3 per cent. was earned.

The passenger traffic last year shows a considerable falling off, which was due chiefly to dull times; but there was an increase of about 11 per cent. in freight business. Considerable reductions in rates were made during the year, however, so that the earnings were about the same as in the previous year, the increase in the net earnings being obtained entirely by diminishing the expenses. The Railroad Commissioners do not consider that there is any probability of a rapid gain, and say in their report that the growth of the business must be very gradual, from the nature of the country and of the people.

The equipment of these roads consists of 272 locomotives, 512 passengers cars, and 8,156 freight cars. Of the locomotives about 40 are of American pattern, but nothing is said in the report as to any comparison between the performance of the different classes. The largest locomotives in use are American consolidation engines with 15 × 18 in. cylinders, and a few Fairlie double-truck engines having four 10 × 18 in. cylinders. Most of the cars are of English pattern, although about half of the passenger cars are long cars carried on two trucks of the American type. The rails in use are chiefly of steel, and vary in weight from 40 to 53 lbs. to the yard, the latter being the heaviest.

COUNTERBALANCING THE REVOLVING AND RECIPROCATING PARTS OF LOCOMOTIVES.

(*Continued from page 54.*)

THUS far we have considered the engine as working without steam in the cylinders. It may be thought that the conditions of working are very materially altered if pressure is exerted on the pistons.

That such is not the case can be shown if it be supposed that we had an engine with a double crank and two cylinders located on opposite sides of the crank, as shown in fig. 13. If the crank should turn without steam in the cylinders, obviously the reciprocating parts of each would exactly balance each other. If steam was admitted to one of the cylinders, so as to turn the crank at the same speed that it was turned without steam on, then it is plain that the movement of the reciprocating parts—their acceleration and retardation, their inertia and momentum—will be the same with steam on as they were without steam. As they balanced each other at the same speed without steam on, they will be in equilibrium when steam is admitted to one or both cylinders.

As it has been shown that a counterweight opposite the crank will balance the movement of the reciprocating parts, and as it is also obvious that one piston, etc., will balance another, we may disconnect one piston and substitute a counterweight to balance the other piston and its connected parts.

It is true that if steam is admitted into the front end *S* of the cylinder, fig. 12, that it will cause some disturbing effect, but it is not due to the motion of the reciprocating parts, but to the pressure of the steam. It would press equally on the cylinder-head *t* and on the piston *P*, and these pressures would balance each other. The pressure on the cylinder-head is, however, communicated to the cylinder and frame, that on the piston to the crank-pin, wheel, and thence to the frame, so that they both act in opposite directions. The only cause of disturbance is due to the fact that the pressure on the cylinder-head is communicated directly to the frame and thence to the axle *A*, fig. 12. As the pressure on the piston is communicated to the crank-pin *c*, we will imagine the spoke *A c k* of the

wheel to be a lever, and that the pressure on the cylinder-head acts against the axle, as indicated by the dart *l*, and that the pressure on the piston is exerted in an opposite direction on the crank-pin at *m*. If *k*, the point of contact of the wheel with the rail, is regarded as the fulcrum of the lever, then one force acting on the end of the lever at *A*, and another equal force acting in the opposite direction at *c*, between the end *A* and the fulcrum *k* will push the upper end of the lever ahead. It is this action which propels the engine. As only a part of the backward force acting on the piston and crank-pin is exerted against the axle *A*, and the whole of that on the cylinder-head acts against the axle, we have an excess of pressure against *t* which acts on the engine frame and tends to push one side of the engine ahead and thus cause nosing, but other than that it has no disturbing effect on the action of the working parts. If we will imagine that the wheels are

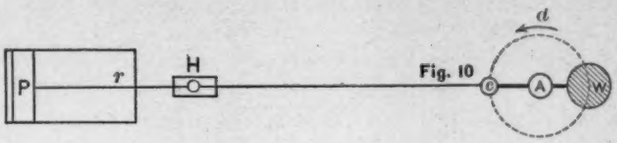

Fig. 10

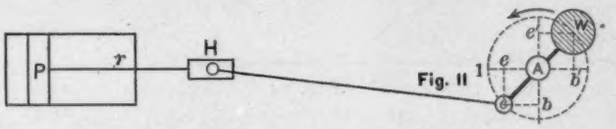

Fig. 11

securely bolted fast so that they cannot turn, then the admission of steam into the cylinders would not disturb or affect their equilibrium.

It is often supposed, too, that by giving an engine lead or compression that the disturbing effect of the momentum of the reciprocating parts is neutralized. That this is not the case will appear if we imagine that the piston should strike the cylinder-head at the end of each stroke. It would thus be brought to a state of rest by a violent blow. If a piece of india-rubber was interposed between the piston and cylinder-head the blow would be less violent, but the energy of the moving parts would still be communicated to the cylinder-head, as it would be if a cushion of steam was interposed, as it is when the engine has lead or compression, and the momentum would then be overcome in a less violent way than it is by a cushion of india-rubber.

But while the motion of reciprocating parts may be balanced by a revolving weight, the latter causes a disturbing effect on the machine, for the reason that the momentum and inertia of the reciprocating parts act in a horizontal direction only, whereas the revolving weight has vertical as well as horizontal movement. Thus, if the crank and counterweight are arranged as shown in fig. 13, the counterweight *W*, in order to balance the reciprocating parts, must be heavier than the weight concentrated at the crank-pin *c*, consequently, the counterweight exerts more centrifugal force than the weight at the crank does, and when they are in the position represented the weight *W* would exert an upward pressure greater than the downward pressure at the crank. When they are at the dead points, as shown in fig. 10, then if the counterweight *W* is equal to the weight of the revolving parts at *c* and the reciprocating parts, the centrifugal force of the former, and the momentum and inertia of the latter will be just equal to the centrifugal force of *W*. When the crank is between the dead points and the two quarters of its revolution, as shown in fig. 11, the centrifugal force of the counterweight is exerted in a diagonal or partly vertical and partly horizontal direction. Between the two dead points, therefore, a counterweight equal to the weight of both the revolving and the reciprocating parts creates a vertical disturbance, which is greatest at the two quarters of the revolution and increases from and diminishes toward each of the dead points, where it disappears entirely.

The counterweights for reciprocating parts, like those for revolving parts, need not be placed at the same distance from the center of the wheel as the crank-pin, the essential thing in each case being that the products of their weights multiplied into their distance from the center of the wheel should be equal.

As an illustration of the method of calculating this upward and downward disturbance, and to show how it acts, we will take the case of an engine with four driving-wheels 62 in. diameter and 24 in. stroke, at a speed of 60 miles per hour. At that speed such wheels would revolve 325 times per minute. If the reciprocating parts on one side weigh 624 lbs., and if their whole weight is balanced by

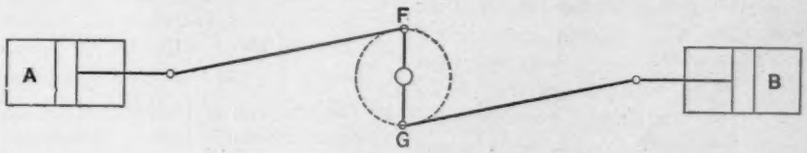

Fig. 13.

weights of 187.2 lbs., in each wheel, the centers of gravity of which are 20 in. from the center of the wheel, then by the rule given the centrifugal force of each weight would be 11,205 lbs., and at 70 miles per hour—not an unusual speed for locomotives—it would be 15,318 lbs. This force, it will be observed, is greater than the weight which in many instances rests on a single wheel of a locomotive, and shows why less than the whole of the reciprocating weight should be counterbalanced.

The manner in which the force of the counterweight is exerted on the wheels while they are in motion is illustrated

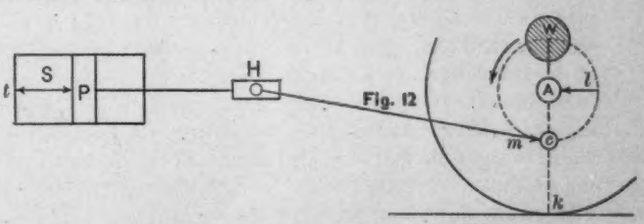

Fig. 12

in figs. 14–18. In fig. 14 a driving-wheel is represented at *D*, with its crank-pin *C* at the forward dead point. *c* is the center of gravity of the counterweight *W*. In this position its centrifugal force is exerted in a horizontal direction only, as indicated by the dart *d*, whose length *o c* will be supposed to represent the magnitude of the force. Figs. 15, 16, 17, and 18 represent the position of the driving-wheel at the end of the first, second, third, and fourth quarters of a revolution, and the circles 4, 8, 12, and 16 show the axle when the wheel is in these positions, and the dotted circles 1, 2, 3–15 represent the inter-

mediate positions of the axle during each sixteenth of a revolution. When the axle is in the position 1, then the center of gravity of the counterweight is at *c* 1, and its centrifugal force acts in the direction shown by the dart *d* 1. Supposing, again, that the length of the dart *d* 1 represents the magnitude of the centrifugal force, and that a

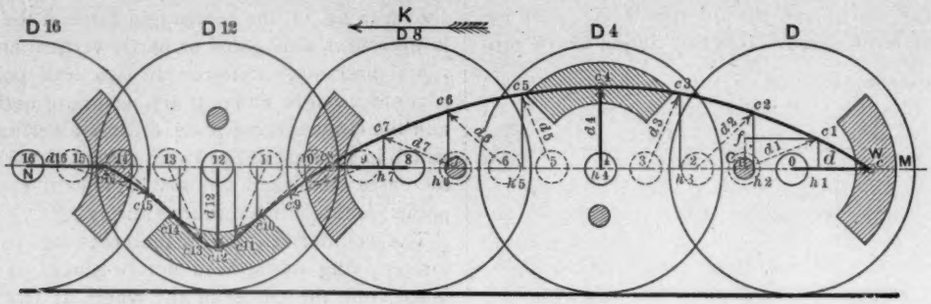

Fig. 18. Fig. 17. Fig. 16. Fig. 15. Fig. 14.

parallelogram *f*, *c* 1, *h* 1, *h* 2, is drawn whose sides are vertical and horizontal and of which *d* 1 is a diagonal, then by the principle of the parallelogram of forces *c* 1, *h* 1 the vertical side will be equal to the vertical component or vertical effect of the force *d* 1. In the same way similar parallelograms could be drawn for the darts *d* 2, *d* 3, etc., but all that is needed to represent the vertical effect for each position of the wheel is to draw vertical lines *c* 2 *h* 2, *c* 3 *h* 3, etc., from extremities *c* 2, *c* 3, etc. of the dart, to the horizontal line *M N* passing through the centers of the axle, and these vertical lines will represent the vertical effect of the centrifugal force of the counterweight in each position, *c* 1, *c* 2, *c* 3, etc., of its center of gravity. If we draw a curve *c*, *c* 1, *c* 2 – *c* 16 through each position of the center of gravity of the counterweight during a whole revolution, its vertical distance above the center line *M N* will represent the upward force exerted by the counterweight, and the distance of the curve below the line *M N* will represent the downward pressure of the counterweight, and the curve will represent to the eye the vertical strains exerted by the counterweight during a whole revolution of the wheel. It will be seen from the diagram that when the wheel is in the position indicated by fig. 14, as already explained, the centrifugal force is exerted in a backward direction—assuming that the engine is running from the right toward the left side, as shown by the dart *K*. When the wheel has turned a quarter of a revolution, as shown at fig. 15, then the centrifugal force *d* 4 is exerted upward ; in fig. 17, *d* 12 acts downward, and at fig. 18 the centrifugal force is again backward.

As the crank on the other end of the axle is at right angles to the one on this side, the centrifugal force of the counterweight on that side also acts at right angles to the one on this side, so that when the counterweight *W* exerts a backward horizontal pressure the opposite one acts vertically either up or down, according to its position in relation to *W*. When *W* acts vertically, as in fig. 15, then the opposite counterweight exerts its force horizontally.

The vertical disturbance of the counterweight may be lessened by balancing only a part of the weight of the reciprocating parts. When this is done there is more horizontal disturbance in the working of the engine than there would be if the whole of the reciprocating parts were balanced, but this is not considered so great an evil as the excessive vertical disturbance which necessarily results when the counterweight is sufficient to balance the whole of the horizontal momentum of the reciprocating parts. Whether a third, a half, two-thirds, or any other proportion of these parts should be balanced is a question which must be largely decided by experience and practical considerations. If a half is balanced it divides the vertical and horizontal disturbance equally, but there is still much difference of opinion with reference to which is the greater evil, vertical or horizontal disturbance.

In another article some other disturbing action of counterweights will be discussed.

NEW PUBLICATIONS.

A Text-Book on Roofs and Bridges: Part II, Graphic Statics: by Mansfield Merriman, Professor of Civil Engineering, and Henry S. Jacoby, Instructor in Civil Engineering in Lehigh University. New York; John Wiley & Sons, 15 Astor Place (price, $2.50).

The first part of Professor Merriman's work has met with general acceptance, and the second part, which forms the volume of 125 pages now before us, seems likely to meet with similar success. Its general plan and object can best be explained by the following paragraphs from Professor Merriman's preface :

The course of instruction in roofs and bridges given to students of civil engineering in Lehigh University consists of four parts : first, the computation of stresses in roof trusses and in all the common styles of simple bridge trusses ; second, the analysis of stresses by graphic methods ; third, the design of a bridge, which includes the proportioning of details and the preparation of working drawings ; and fourth, the discussion of cantilever, suspension, continuous and arched bridges. In the following pages the second part of this course is presented, together with additional matter, so as to form a tolerably complete treatise on Graphic Statics as applied to the discussion of common roofs and bridges.

In an elementary text-book of this kind it is not expected that much will be found that is new except method of arrangement and presentation. Attention is called, however, to the abbreviated processes employed in some of the diagrams for wind-stresses, to the determination of stresses due to initial tension, and to portions of the analysis of maximum moments and shears under locomotive wheel-loads as possessing points of novelty and practical value. These new features are due to the experienced Instructor whose name appears on the title-page in connection with my own ; the larger portion of the text has also been written by him, and the cuts and plates are his work.

The book is divided into three parts, Chapter I treating of general principles and methods ; Chapter II of roof trusses, and Chapter III of bridge trusses. An appendix contains answers to problems. While intended, as stated above, mainly as a text-book for students, the book will be useful to engineers also, who will find its clear statements and style attractive.

As in Part I the book is bound with blank leaves between the pages. These will be found very convenient for students to record permanently such additional notes and computations as may be required in working out the problems.

CARE OF CASH BY AGENTS AND CONDUCTORS; ITS COLLECTION, CUSTODY, USE AND TRANSMISSION TO THE COMPANY'S TREASURY: BY MARSHALL M. KIRKMAN. Chicago; published for the Author.

This is the latest addition Mr. Kirkman has made to the literature of railroad accounts, a field which he has made and occupied so successfully, that it may be said he has no rival therein. Like Mr. Kirkman's former works, the "Care of Cash" is a valuable book to those to whom it is addressed. It has all the merits and all the faults of his previous volumes. The directions, suggestions, forms, etc., are good, but there is a little too much of it. Some day, when the pen of the Author is somewhat worn, and he feels that it will not run quite so fast as he now uses it, he may be induced to make a revised edition of his works, somewhat in the form of the Revised Statutes, and they will be not only a monument to his acute sense of what is good in railroad accounting, but even a more valuable addition to the railroad literature of the country than they are in the form in which they are now published. Still in its present form we can recommend the "Care of Cash" to all those interested in railroad accounts.

PRACTICAL BLACKSMITHING, VOLUME II: COMPILED AND EDITED BY M. T. RICHARDSON, EDITOR OF THE BLACKSMITH AND WHEELWRIGHT. New York; M. T. Richardson, 84 & 86 Reade Street, (illustrated, 259 pages; price, $1).

This is a compilation of articles published from time to time in the *Blacksmith and Wheelwright;* not merely thrown together, however, but carefully arranged and edited. To these Mr. Richardson has added an introduction treating of the history of iron and steel and of artistic iron work.

Volume I was devoted chiefly to shop economy and arrangement, methods of constructing forges, and similar matters. Volume II treats chiefly of tools and of the best and most convenient ways of making them. It is very fully illustrated, and the engravings, though not of the best quality, are generally plain and clear. The book is of the most practical kind, and is full of hints and ideas which must be of value to every blacksmith.

ANNUAL REPORT OF THE CHIEF OF THE BUREAU OF STEAM ENGINEERING, NAVY DEPARTMENT, FOR THE YEAR 1889; GEORGE W. MELVILLE, CHIEF OF BUREAU. Washington: Government Printing Office.

Like the report of the Bureau of Construction and Repair, this report covers a period of great activity in the Navy Department. The mere summary of the designs for new engines prepared during the year occupies a considerable space, and while the report is not very long, it is evident that the Bureau has not been by any means idle. Besides the design and supervision of the new work, no inconsiderable time has been required for the repairs and maintenance of the machinery of older vessels. The recommendations made by the Chief of the Bureau are generally practical and in the direction of improving the service.

ANNUAL REPORT OF THE CHIEF OF THE BUREAU OF CONSTRUCTION AND REPAIR TO THE SECRETARY OF THE NAVY FOR THE FISCAL YEAR ENDING JUNE 30, 1889: CHIEF CONSTRUCTOR, T. D. WILSON, U. S. N., CHIEF OF BUREAU. Washington; Government Printing Office.

This report is of unusual interest at the present time, when so much work is in hand for the reconstruction of the Navy. Necessarily it contains much of the detail of official routine which is required in a report of this kind; but outside of this there is much of interest in its pages. Several of the new ships now under construction are described and illustrated and their present condition is given. A melancholy interest attaches to the excellent engravings of the *Trenton* and the *Vandalia*, lost in the great storm at Samoa.

A careful reading of the report shows the great variety of work that has required the attention of the Bureau, in the care of the old ships and the building of the new ones for the Navy, while the recommendations made for the improvement of the construction plant at the several navy-yards are worthy of careful consideration.

So much has been said of the new ships that many will be surprised to learn that the Navy is decreasing rather than increasing in actual numbers. The new vessels are more powerful and larger than the old, it is true; but their number so far is not great enough to make up for the wooden ships retired by the wear of time and service and the casualties of the sea.

MOTIVE POWER FOR STREET CARS. New York; issued by the John Stephenson Company, Limited.

This neat little book contains the reports presented at the last meeting of the American Street Railway Association on Electricity as a Motive Power and on Motors other than Animal, Cable and Electric, with the discussions on the same; a paper read before the National Electric Light Association on Storage Batteries for Electrical Traction; and a paper on Cable Railroads in Australia. It is illustrated by a number of views of electric and cable cars built by the John Stephenson Company.

The pamphlet is a timely one, putting in accessible shape much valuable information on the subject of replacing animal power on street railroads by some kind of mechanical traction —a question which is now being discussed with interest everywhere.

BOOKS RECEIVED.

ELEMENTARY MANUAL ON STEAM AND THE STEAM ENGINE: BY PROFESSOR ANDREW JAMIESON. London, England; Charles Griffin & Company.

A TEXT-BOOK ON STEAM AND STEAM ENGINES: BY PROFESSOR ANDREW JAMIESON. London, England; Charles Griffin & Company.

INSTITUTION OF MECHANICAL ENGINEERS: PROCEEDINGS, JULY, 1889, PARIS MEETING. London, England; issued by the Institution.

STATISTICAL ANNUARY OF THE UNITED STATES OF VENEZUELA: 1889. Caracas; Printing Office of the National Government.

HAND-BOOK OF FREIGHT ACCOUNTS. HANDLING FREIGHT; THEORY AND PRACTICE OF ACCOUNTS; RULES AND REGULATIONS GOVERNING AGENTS; RETURNS TO BE MADE BY THEM: BY MARSHALL M. KIRKMAN: Chicago; printed for the Author.

COMMERCE OF THE UNITED STATES AND OTHER FOREIGN COUNTRIES WITH MEXICO, CENTRAL AMERICA, THE WEST INDIES, AND SOUTH AMERICA: BUREAU OF STATISTICS, TREASURY DEPARTMENT. Washington; Government Printing Office.

MAP OF THE COUNTRY ADJACENT TO PUGET SOUND, EMBRACING BRITISH COLUMBIA AND THE COUNTIES OF WESTERN WASHINGTON. Seattle, Wash.; Baker, Balch & Company, Engineers.

REVISTA TECNOLOGICO INDUSTRIAL: NO. 12, DECEMBER, 1889. Published by the Association of Industrial Engineers, of Barcelona, Spain.

SEVENTEENTH ANNUAL REPORT OF THE COMMISSIONER OF RAILROADS OF THE STATE OF MICHIGAN, FOR THE YEAR 1889: JOHN T. RICH, COMMISSIONER. Lansing, Mich.; State Printer.

REPORTS OF THE CONSULS OF THE UNITED STATES, ISSUED BY THE BUREAU OF STATISTICS, DEPARTMENT OF STATE: NO.

112, JANUARY, 1890—STEAMSHIP SUBSIDIES. Washington; Government Printing Office.

CENTRAL EXPERIMENTAL FARM, DEPARTMENT OF AGRICULTURE: BULLETIN NO. VI, JANUARY, 1890. Ottawa, Canada; issued by the Department.

HALSEY'S PATENT PORTABLE POWER DRILLING MACHINES: CATALOGUE AND DESCRIPTION. Morristown, N. J.; issued by James T. Halsey, Manufacturer.

ABOUT BOOKS AND PERIODICALS.

AMONG the new books now in preparation by John Wiley & Sons are Part II of Professor McCord's Kinematics; Professor Thurston's Handbook of Engine and Boiler Trials; a Manual of the Steam Engine, by the same Author, and H. C. Godwin's Engineers' Field Book.

Colonel Church continues his articles on John Ericsson in the March SCRIBNER, and among the illustrations will be reproductions of his first rough pencil sketches embodying the ideas subsequently developed in the *Monitor*.

Mr. William M. Goldthwaite, already well known as a publisher, has succeeded to the business of Hyde & Company, and has established himself at No. 107 Nassau Street, New York. His specialty is the publication and dealing in maps, atlases, charts, and other works in the geographical line, and his object is to make his office a bureau of geographical information. Such an intention deserves to succeed, and there is little doubt that it will do so.

The ECLECTIC MAGAZINE reaches us this year with a new cover and a new dress, but the contents are as good and the selections as ably made as they used to be when Mr. William Shakespeare presided over the title-page as their representative.

The paper of HARPER'S MAGAZINE for February which will be of most interest to many of our readers is the Talks with Edison, giving his reminiscences as to his earlier inventions and something about his methods of work. The army series is continued by an article on the British Army, by General Lord Wolseley. This series will be continued in the March number by the Army of the United States, written by General Wesley Merritt.

The WESTERN ENGINEER is a new monthly, issued by that enterprising firm, the Pond Engineering Company, of St. Louis. The number at hand contains some valuable matter, including a paper on Steam Plants for Electrical Service, by William H. Bryan.

The Power of Congress over Rates of Interstate Carriers, by John Totyl, in the OVERLAND MONTHLY for February is a severe criticism of the Interstate Commerce law, and an attempt to raise again the issue of the constitutionality of the law. In an Empire in Ruin, in the same number, John Bonner gives rather a gloomy picture of the present material and political condition of China, with some account of the causes which have led to it.

UNIFORM STANDARD TIME.

AT the annual meeting of the American Society of Civil Engineers in January, the special Committee on Uniform Standard Time—consisting of Messrs. Sanford Fleming, Charles Paine, Theodore N. Ely, J. M. Toucey, T. Egleston and F. Brooks—presented a report from which the following extracts are taken:

The last annual report of the Committee, together with other documents bearing on the question, have been published in pamphlet form and widely circulated. The railroad managers and others were asked to state their views as to the adoption of the new notation by the railroads of the country.

The Committee have to announce the receipt of 237 replies to the circular issued. Of these 17 are unfavorable and 220 favorable to adoption of the proposed change.

Persons answering the circular were requested to indicate the year when, in their opinion, the change might be effected, allowing sufficient time for such preparation as might be deemed necessary.

In the 220 favorable replies received, 27 named the year 1892; 68 the year 1891; 95 the year 1890; 30 gave no date.

Thus it appears that none of these replies give a later date than 1892, nearly half the whole number named the present year, and if we assume, what is highly probable, that the 30 persons who mention no date would concur in the views of the majority, no less than 84 per cent. of the whole number think the change might be effected not later than the year 1891, should a general assent be first expressed.

The last annual report was copied in the technical journals with favorable endorsements.

It has not come to the knowledge of the Committee that any journal has at any time expressed any opposition to the new notation.

The Committee has considered it advisable to tabulate the replies recently obtained with those received in previous years. It thus appears that between 500 and 600 prominent men in every section of the country have responded to the Society's interrogations, and of these an exceedingly small percentage have given expression to an opinion adverse to the early adoption of the new notation.

The list of those approving it includes 384 officials of railroads. The aggregate length of the railroads with which these officers are connected amounts to fully 135,000 miles, and although all of the officers on each line have not yet expressed an opinion, the Committee are inclined to believe that when heard from the greater number of them will express the same views on this question.

While the Committee ventures to congratulate the Society on the highly satisfactory results of the inquiries so far made, they are of opinion that, as the matter concerns so many people, it will be best to proceed with wise deliberations; they therefore beg leave to suggest that the ascertained facts be communicated to the journals above mentioned, and that further efforts be made to secure an expression of the greatest possible unanimity, especially among railroad men.

General unanimity satisfactorily established among those who control the railroads of the country, it will then be fit and proper for them to take decisive action. It is obvious that the change should be effected simultaneously six or twelve months after an agreed date, and the proper authority to determine the date is the General Time Convention.

The Committee cannot doubt that when the change to the new notation comes to be satisfactorily established the entire railroad system and the community generally will recognize that a public boon has been conferred not less valuable than that already conferred by the adoption of standard time.

The Committee has the satisfaction to report that the hour-zone system is now approved by the railroad administration in Austro-Hungary, soon to be followed, it is believed, in Germany, Italy and Switzerland. The reckoning of time in Great Britain and Sweden is already in harmony with the hour-zone system. The 24-hour notation has been adopted for railroad service in China.

The Committee deem it proper to bring to the notice of the Society that the Government of the United States has so far taken no action on the resolutions and recommendations of the Washington International Conference of 1884. As the reforms in time-reckoning so largely adopted and proposed to be adopted in this country are in harmony with the resolutions of the Conference, and as questions are constantly arising as to the legal aspect of standard time, it would be in the public interest to have the recommendations of the Conference authoritatively recognized,

and also perhaps some satisfactory statutory enactment legalizing the changes made and contemplated in respect to the reckoning of time.

The Committee respectfully suggest that the Society should memorialize the United States Government on this subject.

A form for this proposed memorial and a list of the railroad officers approving the 24-hour system accompany the report.

THE DEVELOPMENT OF ARMOR.

By First Lieutenant Joseph M. Califf, Third U. S. Artillery.

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(*Continued from page 89.*)

VIII.—PRACTICAL APPLICATION ABROAD (CONTINUED).

The next step in English construction is represented by the *Nile* and *Trafalgar*, in which the displacement is carried from the 9,000 tons of the *Collingwood* to about 12,000 tons. The armored belt is extended to 230 ft., with an armored citadel 193 ft. long in the central fort of the ship, with a turret at either end, mounting two 68-ton guns each, with a maximum thickness of armor amidships of 20 in., thinning to 14 in. at the ends. Instead of the long, unprotected space between the turrets, as in the *Admiral* class, there is a central box battery, with 5-in. armor, affording protection for the secondary battery as against guns of moderate caliber. These vessels do not differ radically from the new turret battle-ship shown in fig. 4.

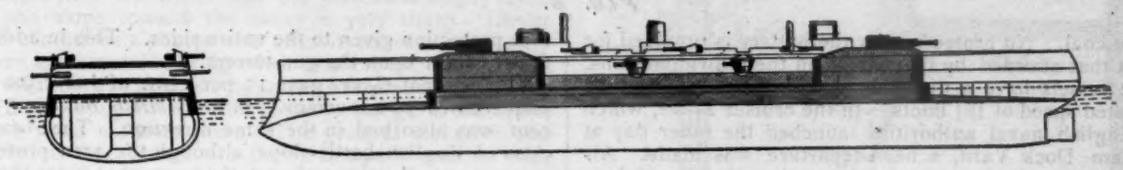


Fig. 5.

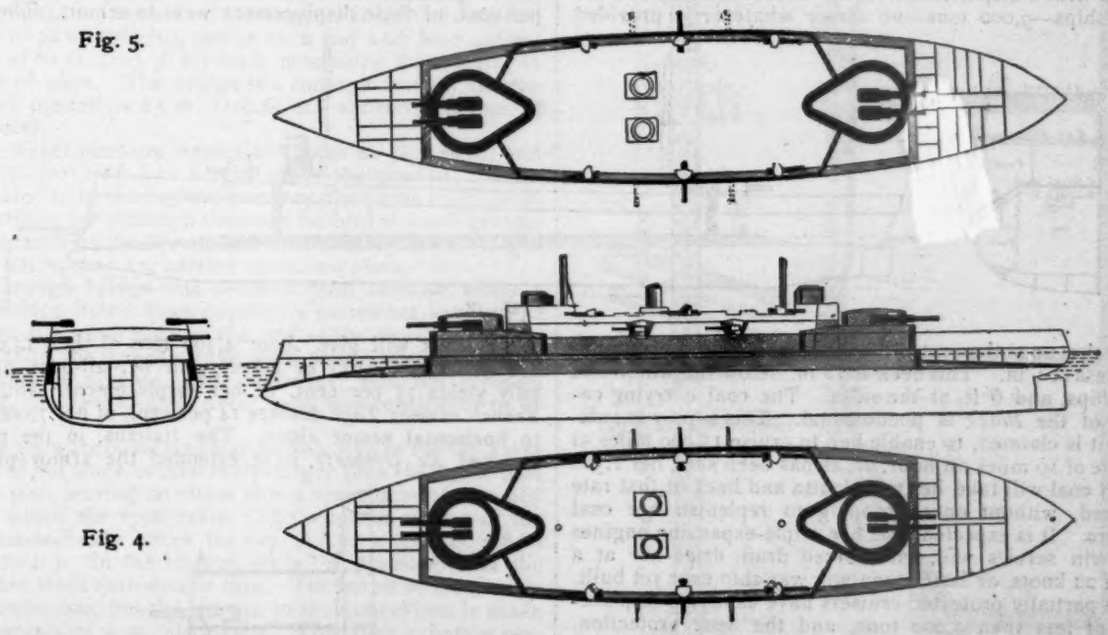


Fig. 4.

In November of tast year the British Board of Amirally decided upon the construction of eight new battle-ships during the coming year, of about 14,000 tons displacement. After considerable discussion it was decided that seven of these ships should be barbette and one turret. Except in this regard the ships of the two designs are to be identical in their details. The advantages claimed for the barbette over the turret designs are that the guns are carried some 7 ft. higher above water, and that the weight saved from the turrets can be utilized in adding to the height of the redoubts in which the turret bases stand. They lack, however, the protection given to the guns in the turret ship. The new designs are expected to carry 4,550 tons of armor. Figs. 4 and 5 show the manner of armor distribution. The armor protection is a belt of 18 in. compound armor, two-thirds the length of the ship, 8½ ft. in width, 3 ft. above and 5½ ft. below the water-line, with transverse armored bulkheads; a 3-in. steel deck, and a strong protective under-water deck before and abaft the belt. Above the belt the broadside guns are to be protected by 5 in. of steel armor, 9½ ft. in width. The turrets are to have 18 in. and the barbettes 17 in. of compound armor. After all the criticism that has been indulged in at the expense of the Italian Government for constructing the huge vessels of the *Italia* type, England is now committed to the same line—the new ships falling but little short of the tonnage of that vessel. The cost of one of these new ships, including armament, will reach very nearly a million pounds sterling.

Next in importance are the belted or armored cruisers, the distribution of armor upon which is shown in fig. 6, representing the English ships of the *Australia* class, which may be taken as a type of the best of this type of ships. Here we have a water-line belt of 10 in. of armor, extending about 200 ft. over the vitals of the ship; at the ends of the belt a 16-in. compound armored bulkhead, while on top of this belt is a flat protective deck of 2 in. steel. Where the belt ends this deck slopes down to the sides with an increased thickness of one inch, and also slopes longitudinally to a point considerably below the water-line. This belt, 5½ ft. in width, covers 18 in. above and 4 ft. below the load water-line. With a displacement of 5,000 tons, a speed of 18 knots, a liberal coal supply, and means for discharging torpedoes, the English claim for them superiority over any vessels of their kind afloat.

In the protected cruiser side or vertical armor is wholly wanting, and as a substitute for the protection of magazines, machinery, boilers, etc., we find a greater or less thickness of horizontal armor laid upon a deck running from end to end of the vessel, with a level amidships of about that of the water-line and sloping to the sides at a

point considerably below. Fig. 7 represents the English vessels of the *Mersey* class. In them the steel deck is 2 in. thick amidships and 3 in. on the slope, which strikes the side 4 ft. below the load water-line. The boilers, etc., are, as shown in the cut, protected by many feet of thick-

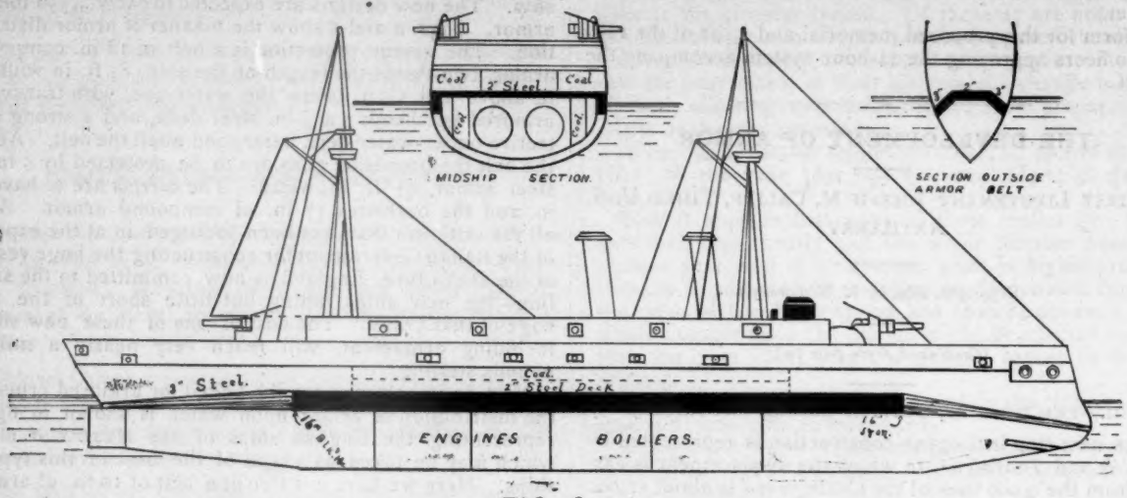


FIG. 6.

ness of coal. No protection for the battery is provided for except that afforded by the shields on the individual guns. These vessels have a displacement of 3,500 tons and an estimated speed of 18½ knots. In the cruiser *Blake*, which the English naval authorities launched the other day at Chatham Dock Yard, a new departure was made. Although with a displacement equal to that of many of their battle-ships—9,000 tons—no armor whatever is provided

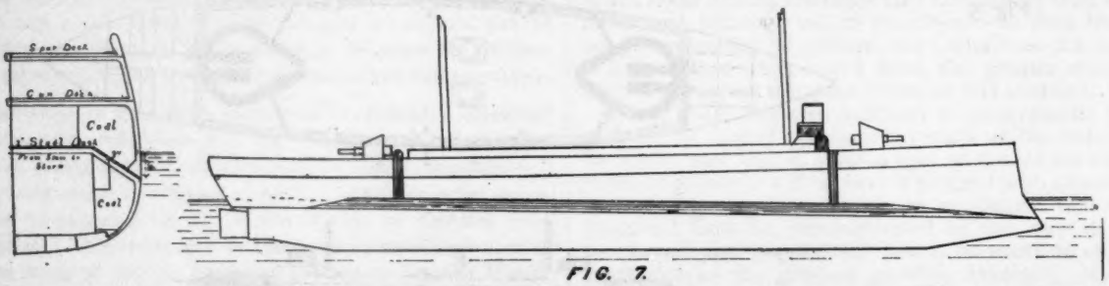


FIG. 7.

except that upon the protective deck, which has a maximum thickness of 6 in. This deck is 18 in. below the water-line amidships, and 6 ft. at the sides. The coal carrying capacity of the *Blake* is phenomenal. This supply is sufficient, it is claimed, to enable her to cruise 15,000 miles at the rate of 10 miles an hour, or, as has been said, her 1,500 tons of coal will take her to Calcutta and back at that rate of speed, without once stopping to replenish her coal bunkers. It is expected that her triple-expansion engines and twin screws will, with forced draft, drive her at a rate of 22 knots, or faster than any war-ship ever yet built.

The partially protected cruisers have usually a displacement of less than 2,000 tons, and the deck protection, which is of the same character as that of the larger cruisers, extends ordinarily only over the vitals of the ship, something more than one-half its length. With this deck and a proper disposition of the coal the machinery is all fairly well protected.

Reference has been made to the employment of cellulose, or wood-armor, to prevent the entrance of water following a shot at or below the water-line. The method of employing this material, in some of the new French cruisers, is shown in fig. 8.

It has been said that the first iron-clad came from the hands of its builders clad in a complete suit of armor. Gradually this suit was curtailed a little here and a little there until in the *Admiral* class of English ships, and the Italian ships of recent construction, little attempt was made except to protect the gun-towers of the heavy guns and the ammunition tubes. If, however, we look at the model of the recent English battle-ships planned within the past twelve months, we shall find a return toward first designs in the amount of space sought to be protected. Better still, the reconstructed plan of the *Dupuy de Lôme* will show as a ship that is almost a second *Gloire*—a 4-in. armor protection given to the entire sides. This in addition to the armor upon the gun-towers.

The original *Gloire* gave 15 per cent. of her 5,500 tons displacement to her armor. In the *Amiral Baudin* 33 per cent. was absorbed in the same direction. The *Admiral* class of English battle-ships, although the area protected was very small, it was of such thickness that more than 30 per cent. of their displacement went to armor. The new battle-ships will give about 4,500 tons of their 14,000 to armor. The *Dupuy de Lôme*, with her all-over armor, only yields 15 per cent. of her displacement, while the French cruiser *Tage* devotes 14 per cent. of her 7,000 tons to horizontal armor alone. The Italians, in the reconstructed *Re Umberto*, have extended the armor plating

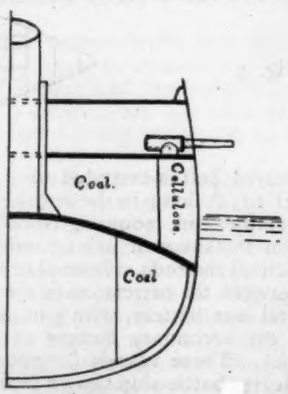


FIG. 8.

from the steel protective deck upwards to the upper deck, giving moderate protection for the secondary battery, and covering two-thirds of the length of the vessel from below the water-line upward.

(TO BE CONTINUED.)

THE SOULEUVRE VIADUCT.

[(Condensed from *Le Genie Civil.*)]

THE line from Vire to Caen, of which the first section was opened in 1888, and the remainder is under construction, passes through the rough and irregular region known as the Norman *Bocage*, where the undulating nature of the ground and the unequal hardness of the rocks in the hills made the problem of location particularly difficult and interesting. The final location was one selected after a number of preliminary surveys and much consultation. It is the line which was considered not only the least costly, but also the most favorable for traffic, and may be called the hill line, following the general line of the high grounds and not that of the valleys. The most expensive work required for this line was the viaduct here illustrated, and the cost of this, it was considered, was more than balanced by the reduction effected elsewhere by avoiding the deep cuttings and the rock-cutting which would have been required in the valley location.

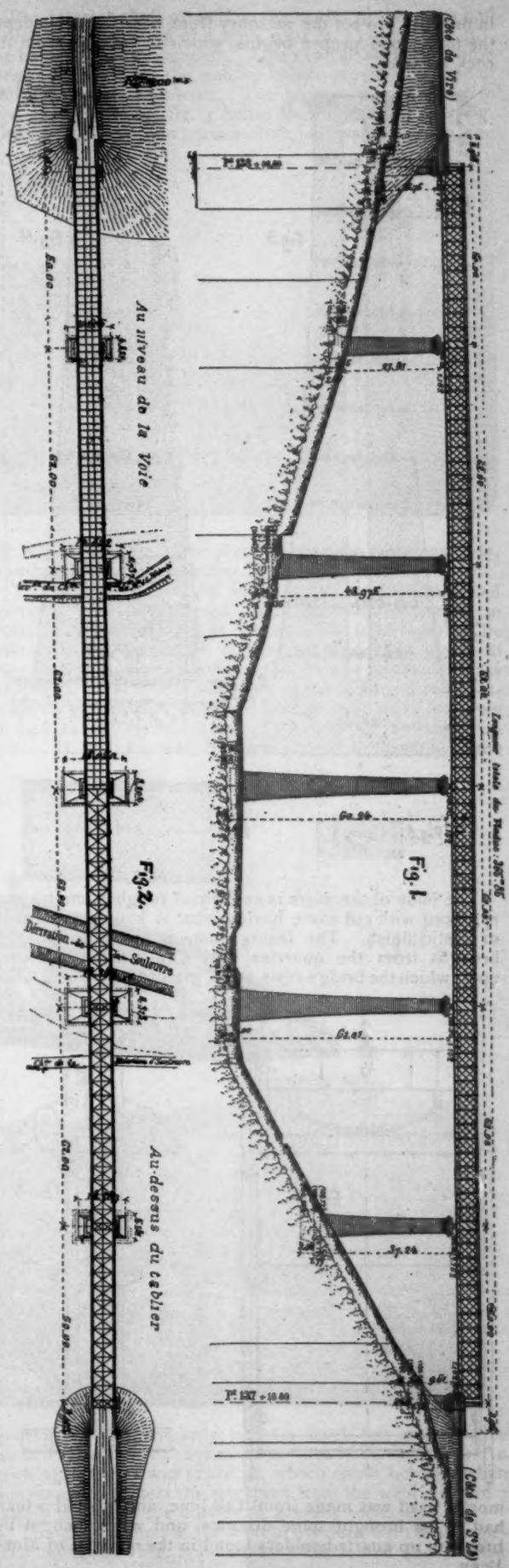
The Souleuvre, a small tributary of the river Vire, runs through a deep valley, the section of which at the point where the new railroad crosses it resembles an irregular trapezoid, the upper and lower sides of which are respectively 400 and 80 m. (1,312 and 262.4 ft.) and the height 70 m. (229.6 ft.). On either side the plateau is nearly level, and the slope toward the valley is very sharp. Under these conditions a choice was offered between a masonry viaduct and a metallic bridge with continuous girders. The first solution was rejected on account of economy, and the plan finally adopted was of a metallic bridge in six spans resting upon masonry piers. The general elevation and the plan of this viaduct are shown in figs. 1 and 2. The total length is 366 m. (1,200.48 ft.). The opening of 348 m. (1,142.44 ft.) between the abutments is divided into two spans of 50 m. (164 ft.), one at each end and four central spans of 62 m. (203.36 ft.) each, measuring from center to center of piers. The bridge is a through bridge, and the level of the rail is 63 m. (206.64 ft.) above the bottom of the valley.

The upper piers are respectively 60.50 m. (198.44 ft.) and 61.47 m. (201.62 ft.) in height above the ground. These are stated to be the highest masonry piers ever built for an iron bridge, for although there are bridges of much greater height, such as the Kinzua and the Kentucky River bridges in America, they are carried upon iron piers.

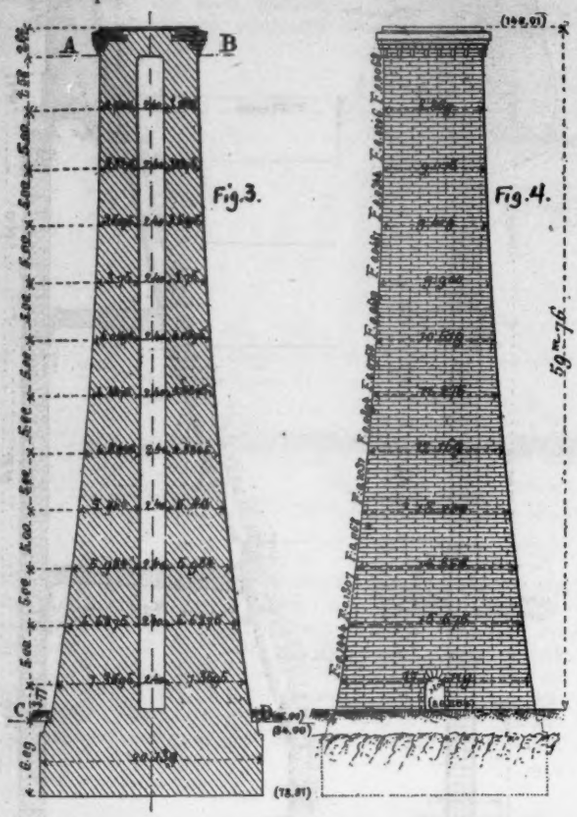
A through bridge was decided upon because, while a deck bridge would have required a somewhat less height of pier, the excavation at the end of the bridge of a way or channel for launching the span would have required a considerable expense, and, moreover, with the through bridge, the danger from derailment was considered to be less.

The piers are of rectangular section, and at the top carry a cap of cut stone considerably larger than the upper part of the pier, leaving on either side a space around the bed upon which the span rests. The smallest section of the pier, immediately below the cap, is 8.80 × 4.00 m. (28.86 × 13.12 ft.). In the highest piers the dimensions at the base are more than double this. The batter of the piers is not continuous, but the change in the dimensions is made at intervals of 5 m. (16.40 ft.). The effect is hardly perceptible to the eye, and looking at the piers from the side of the valley the line seems to be continuous and the taper uniform. On account of their exceptional height a large allowance was made in building these piers for resistance to wind-pressure. They were also designed in such a way as to reduce their size to a minimum, at the same time leaving them of such dimensions that the masonry should not be exposed to any undue strains.

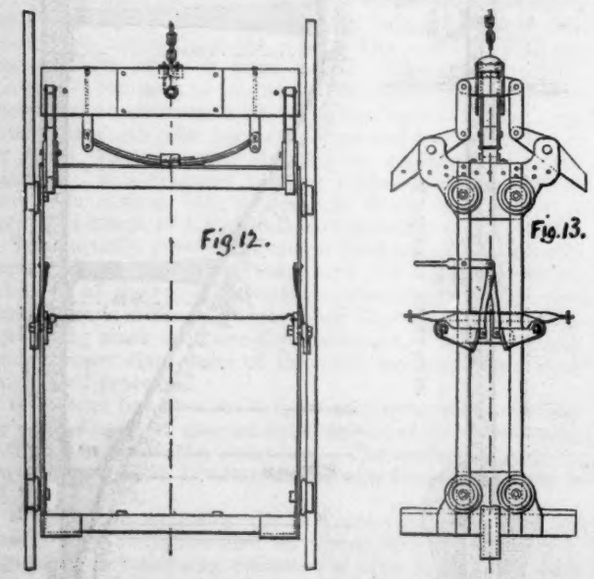
All the piers and both abutments are founded directly upon a schistous rock of very hard nature, but with its strata inclined at an angle of about 45°, and having occasional seams filled with clay, so that it was necessary for some of the piers to excavate for some distance below the surface. The profile adopted for the piers—which is approximately that of a parabola of the second degree with horizontal axis—is continued below the surface for a meter



in order to protect the masonry from frost. At this depth the foundation proper begins, which is built up from the rock in steps.

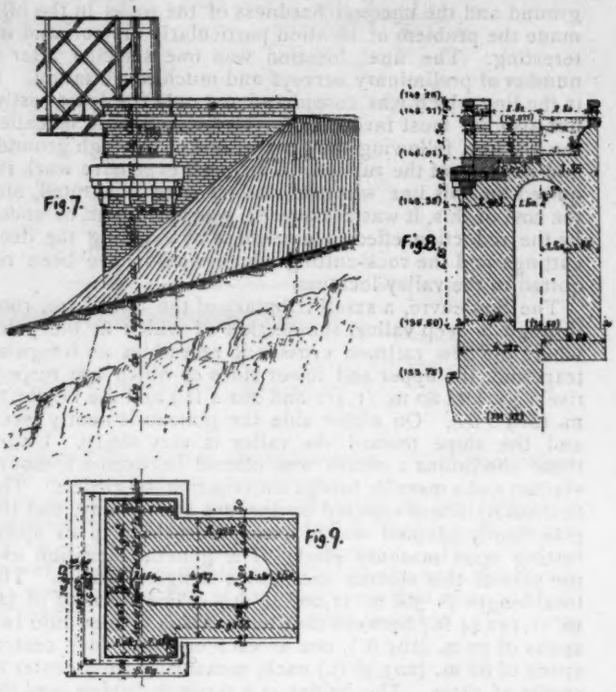


The body of the piers is entirely of rough stone masonry, faced with cut stone having what is known as a rough or rustic finish. The facing stone is of a sort of marble brought from the quarries near Coutances. The caps upon which the bridge rests are of granite from Vire. The



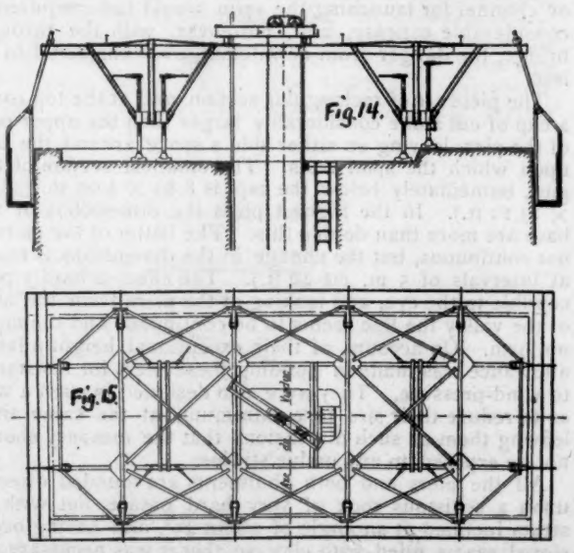
mortar used was made from Teil lime, and of sand which had to be brought some distance, and was procured by breaking up quartz boulders found in the quarries of Mont Beny.

As most of the material had to be brought from a distance, in order to save as much as possible the cost of transportation, the railroad line was completed to the edge of the valley before work on the viaduct was begun. From the end of this line an inclined road—shown in fig. 10—was constructed by which cars could be sent down into the valley. This inclined road was one meter gauge, and was a temporary line of the Decauville system, and 1,400



m. (4,952 ft.) long; it was a cable road worked by a stationary engine placed at the top of the hill. The machines for breaking the stone, working the sand, etc., were placed on a small plateau about half-way down the hill, which can also be seen in fig. 10.

One interesting part of the work was the plan adopted for hoisting the material to the top of the piers. Until these piers reached a point about 30 m. (98.40 ft.) above the ground the stone was taken up by an ordinary derrick and steam-hoist. Above that level the hoisting was done in the interior of the pier—the large piers being made hol-



low, as noted hereafter—by a cage somewhat similar to those used in mine shafts for hoisting material; the hoisting rope passing below over the drum of a hoisting engine and above over pulleys supported on a frame. The guides for the cage consist of U-shaped irons, one placed on either

side, and held in place by bolts embedded in the masonry. Figs. 12 and 13 show the hoisting cage used, fig. 12 being a front elevation and fig. 13 a side view. The small wagons containing stone or mortar were run upon this cage at the bottom through an archway left in the side of the pier, and at the top they were rolled from the cage and

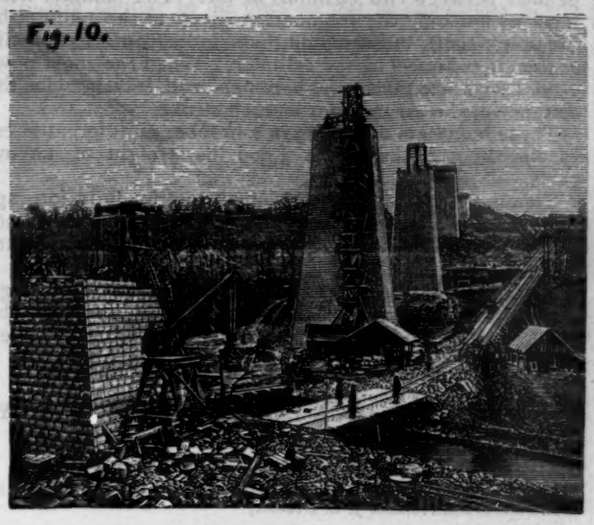


Fig. 10.

discharged upon the platform, the wagons being at once returned. The hoist served also for carrying the workmen up and down, but for use in case of accident a wooden ladder was also built up. The cage was provided with safety brakes or clutches, which would at once stop it in case of the breaking of the rope. These safety brakes were automatic, and in case of their failure to work an additional brake was provided, which could be worked by hand. As the height of the piers was continually changing, and as the engineer, therefore, could not tell exactly by experience when to stop the cage either at the top or bottom, as in the case of a mine shaft of fixed depth, an electric signal was provided by which the engineer could be notified when to stop and start, and by it the hoisting cage could be stopped at any point.

The interior shaft or well in the center of the piers had a rectangular section of 1.20 × 2.40 m. (3.93 × 7.87 ft.), the corners being rounded. This central shaft left room for the cage and for the wooden ladder provided in case of accident, as noted above. The highest pier is shown in figs. 3, 4, 5, and 6; fig. 3 being a section of the pier, fig. 4 an elevation, fig. 5 a cross-section just under the cap, and

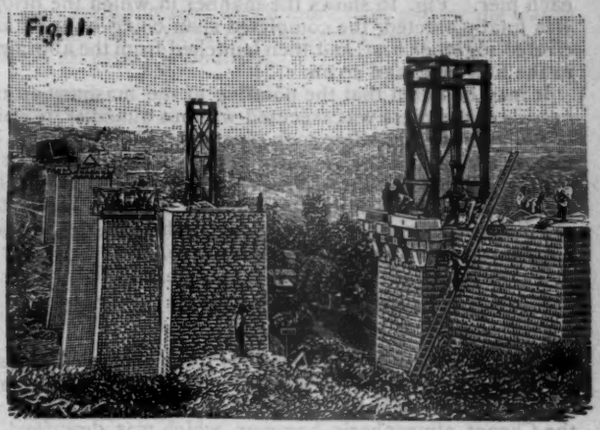


Fig. 11.

fig. 6 a plan. The other piers were of the same construction in all respects, differing only in height.

The platform at the top, upon which the workmen and material were carried, was a light frame of iron, made in sections for convenience of carriage, and held together by bolts. It rested upon the masonry of the pier by means of four feet, each foot consisting of a pair of hydraulic jacks having a lift of one meter, so that the platform could always be kept level. This platform or false-work is shown in figs. 14 and 15, fig. 14 being an elevation and fig. 15 a plan. It will be seen that by the aid of these jacks the platform could not only be kept level, but would leave sufficient room for the masons to work underneath it. An awning or cover was provided, which could be used when necessary to protect the workmen from the weather, and a safety railing on the outside to prevent accidents.

The construction of the abutments does not require special mention. Fig. 7 shows an elevation of one of these

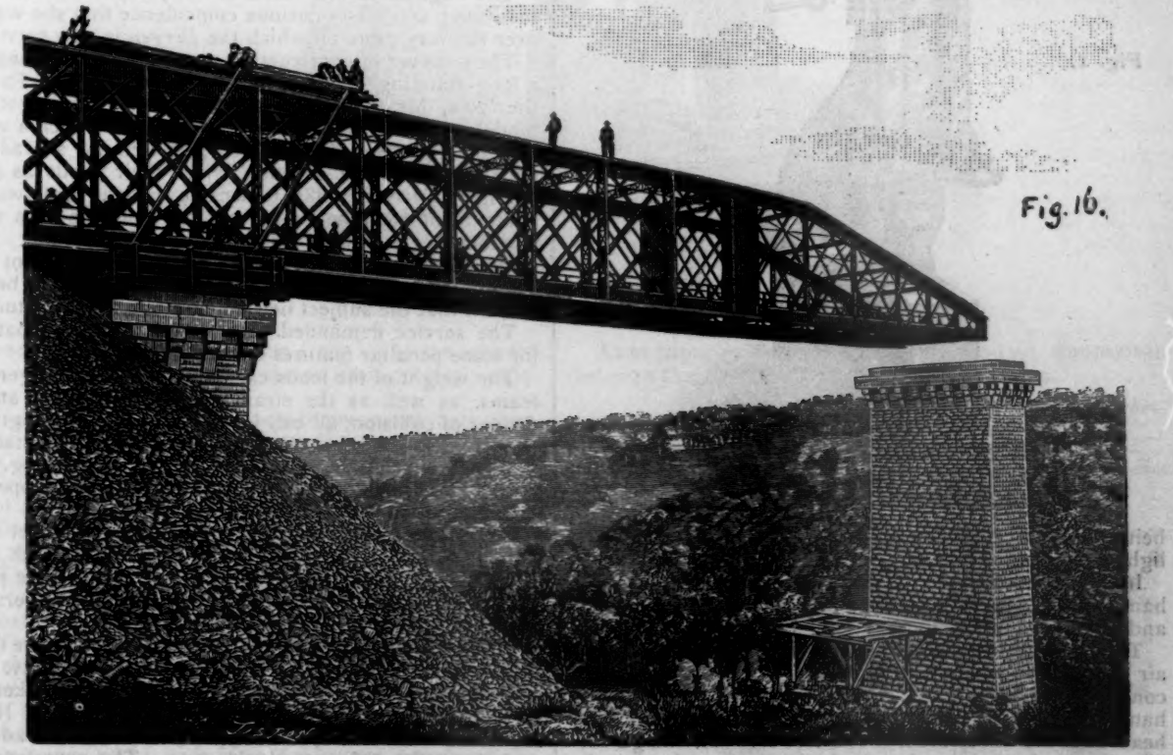


Fig. 16.

abutments, fig. 8 a section, and fig. 9 a plan showing the manner in which the masonry was constructed and the bed or seat upon which the end of the span rested.

Figs. 10 and 11 show two views, one taken from either side of the valley, of the piers while under construction. It will be noted that in addition to the interior shaft a scaffolding or false-work was constructed on one side of each pier. Fig. 16 shows the manner in which the bridge was finally erected, the completed span being built up and riveted together first, and then launched from the abutment to the first pier, and so on.

It may be noted that the pointing of the masonry on the outside of the piers was executed without difficulty, in spite of the great height, after each pier had been completed, by means of a suspended platform upon which two masons at a time worked. These frames was suspended by cables from the cap of the pier, and could be lowered and raised at will by the masons themselves. They were supplied with mortar by a separate hoisting rope.

THE GLOSSOP PNEUMATIC HAMMER.

THE accompanying illustrations show a power-hammer made by the Glossop Pneumatic Power Hammer Company, Birmingham, England. It is of much the same type as the Chenot atmospheric hammer, which was described in the JOURNAL for April, 1889, page 165, an air cylinder

Fig. 1.

being in both substituted for the springs often found in light power hammers.

In the accompanying illustrations fig. 1 shows a small hammer, and fig. 2 a larger hammer with double standards and a separate anvil-block.

The special feature of this hammer is a direct-acting air cylinder, to which a reciprocating motion is given by a connecting-rod and crank, driven by a pulley and belt. The hammer-head is attached to the piston-rod, which hammer-head and the air cylinder move between vertical guides. The front valves of the air cylinder are automatic; but the valves at the back of the air cylinder are worked and regulated by hand or foot, according to the size of the hammer and the class of work to be done, and are entirely under control. When the belt is on the fast pulley, a vertical reciprocating motion is given to the air cylinder, thus moving the piston, with its rod and hammer-head, up and down. By movement of the treadle or handle, the valves at the back of the air cylinder are operated on and the hammer-head held stationary, although the cylinder continues to run at full speed. At any moment, therefore, by simply moving the treadle or handle, the lightest or heaviest blow can be struck, at the operator's will. The front valves admit sufficient air at each stroke to keep the piston suspended between two cushions of air. The hammer-head receives not only the momentum given to the cylinder by the crank-shaft, but also additional force from the elasticity of the air confined in the cylinder. When the most powerful blows are given, the hammer-head travels twice the distance of the air cylinder at each stroke.

These hammers are made in a number of different sizes, varying from 50 lbs. up to 2,000 lbs. weight of moving parts.

This is a compact and convenient tool for light forging, and may be used in many places where the work is not heavy enough to warrant the establishment of a steam hammer.

Whether this type of hammer presents any advantage over spring hammers of different patterns, such as the Bradley, the Bouhey and others, is probably an open question.

PERFORMANCE OF A DOUBLE-SCREW FERRY-BOAT.

[Papers read before the American Society of Mechanical Engineers, by E. A. Stevens and Professor J. E. Denton.]

I.—THE FERRY-BOAT: BY E. A. STEVENS.

THE first propeller-boat used for ferry purposes was constructed in the first decade of this century by my grandfather, John Stevens, and made a run between Hoboken and Barclay Street, New York, my uncles, John C. Stevens and Robert L. Stevens, acting respectively as pilot and engineer.

The engines of this vessel are at present in the Stevens Institute; and it is a curious coincidence that she was run over the very route on which the *Bergen* is now serving.

The problem of constructing a screw ferry-boat has been a long-standing one with the Hoboken ferries. Early in the '70's, Mr. Francis B. Stevens, of Hoboken, got up a model and some preliminary drawings for such a vessel. The management, though not prepared for so radical a departure, kept the question before their minds as a possibility. Early in 1885 it became evident that two new boats must soon be built, and the question was raised whether they should be made propeller boats or not. With some reluctance it was decided that there was not sufficient time to mature the necessary plans, as it became evident that the subject needed careful and close study.

The service demanded of a New York ferry-boat calls for some peculiar features of construction.

The weight of the loads carried, both in passengers and teams, as well as the strain caused by the ice, and the danger of collision, all call for a hull of great strength and rigidity. Beyond this, the vessel must have great stability, to resist burying by the head as well as heeling. She must be able in floating ice, and should attain a speed of about 12 miles an hour in service.

The main characteristics of the *Bergen's* model are a full flaring upper body, fine under-water body, with a full water-line, a sharp V-shape midship section, and the peculiar cutting away of the ends to bring the rudders and screw within the perpendicular of the stems.

The shape of the water-lines and upper body were determined by consideration of power in ice and stability.

The midship section, in order to give an unbroken line for the shafting, had to have a certain depth. It was found that with the required displacement the form adopted was about the only practicable one. The experience on the Hoboken Ferry, moreover, had been very favorable to a sharp V section. The older wooden boats, built on a perfect V section, gave excellent results, while of the iron and steel boats, the *Orange* and *Montclair*, which more closely approach that section, gave better results than the other boats, which had a semi-circular section; and, as far as could be judged, than the West Shore and the Penn-

sylvania Railroad ferry-boats, with straight sides and a flat floor.

The experience on the Hoboken Ferry, with balanced rudders hung under the keel and supported from above, having been very favorable both as regards efficiency, strength, and ease of repair, it was decided to use a rudder as nearly similar to the ones in use as conditions would allow.

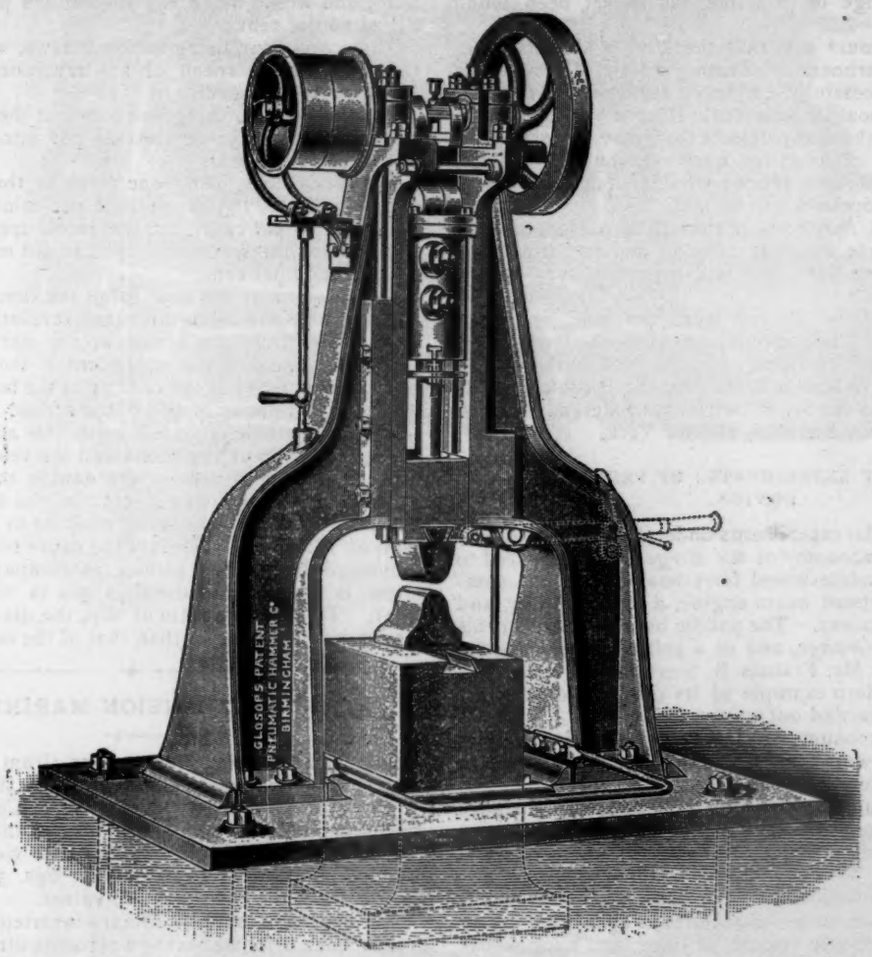
The form with the ends of rudder-stock supported in the shoe, appeared most suitable, and the fixed rudder in the more expensive, the engine decidedly less so, with the same power.

The engines and boilers of the *Orange*, 500 H.P., cost about the same as the *Bergen's*, 660 H.P.

I might add here that the *Bergen* is, if anything, more powerful than necessary.

In cost of operation it was found that, in a six weeks' run, the saving in coal would more than pay for the wages of an oiler and the extra lubricators used. Whether an oiler is necessary is doubtful.

Fig. 2.



bow seemed to promise protection from ice to the forward screw. This arrangement has shown itself perfectly satisfactory in practice.

The question as to motive power presented four alternatives :

1. One engine, driving a line of shaft with universal flexible joints, there being an angle in the shaft on each side of the engine, as proposed by Mr. Cowles.

2. One engine, without such joints, and with a straight shaft, as in the *Bergen*.

3. Two engines, each driving independent shafts at an angle to each other, as in the *St. Ignace*, and I believe in the boats built by Brady.

4. Two engines, either with or without flexible joints in their shafts, driving two propellers at each end, as in the Mersey boats.

This last plan was rejected on account of the lesser protection from ice afforded the screws, and the fear of trouble in riding upon racks, as is often done when entering a slip with a strong wind and tide.

The advantages of the first and third methods were a deeper submersion of the screw and a flatter midship section. The disadvantages were the insecurity of the flexible joints in the first method ; and in the third, the increased cost of construction and operation.

The cost of construction on the plan adopted has shown an advantage in the case of the screw. The hull is slightly

As to capacity, the following table shows a comparison between the *Bergen*, *Orange*, and *Moonachie :*

	Bergen.	*Orange.*	*Moonachie.*
Date when built.....	1889.	1887.	1877.
Material of hull.....	Steel.	Steel.	Wood.
Type of engine.....	Triple-expansion Propeller.	Low-pressure beam.	Low-pressure beam.
Size of cylinders.....	18½ in. / 27 in. / 42 in. × 24 in.	46 in. × 10 ft.	44 in. × 10 ft.
Working pressure.....	160 lbs.	45 lbs.	30 lbs.
Length on load water-line.....	200 ft. 0 in.	217 ft. 0 in.	200 ft. 0 in.
Beam " "	32 " 2 "	32 " 0 "	32 " 0 "
Beam over guards	62 " 0 "	62 " 0 "	62 " 0 "
Draft, hull to base line.....	8 " 10 "	7 " 8 "	8 " 0 "
Displacement to load water-line.	560 tons.	655 tons.	550 tons.
Displacement per in. at l. w. l..	12.6	....	....
Space available for passengers..	4,330 sq. ft.	3,791 sq. ft.	3,335 sq. ft.
" " " teams.....	3,448 " "	3,940 " "	3,380 " "
Number of seats for passengers,	296	254	236

It is to be noted in case of the *Bergen* that the space is more available, especially as regards teams, her team capacity being greater than the *Moonachie's*, and almost equal to the *Orange's*.

A decided advantage in the *Bergen* is the ease with which she can be unloaded, the saving in the crowded hours of travel being very considerable.

In point of handling, the *Bergen* compares very favorably with any ferry-boat on the river. Her greater draft makes her exceptionally steady on her helm, while it is found that she can turn as readily as other boats.

She can stop in a shorter distance notwithstanding her higher speed.

The defects that have been found are not incident to the design, and while there are many departures that will be made in the engine in the next boat built, the hull will be practically unchanged, and no alteration in the engine involving any change in principle has as yet been found advisable.

In closing I would say, that the *Bergen* should be regarded as an experiment in adapting a style of propulsion that has been successfully employed elsewhere to the purposes of a ferry-boat in New York Harbor. Whether use in heavy ice will show any defects that may require modification is as yet an unsettled question; but we feel full confidence that no more serious trouble than a change in the type of the propellers will be met.

Practically, the *Bergen* is preferred by passengers and pilots alike. While the boat is by no means perfect, she is the best boat we have, and will furnish a type for our future boats.

The engines of the *Bergen* were designed by Mr. J. Shields Wilson, of Philadelphia. A number of engineers gave us advice and encouraged us by their confidence in the plan of building such a boat. Among the latter I may mention Mr. Frank Kirby, of Detroit, and Messrs. Herman Winter and Andrew Fletcher, of New York.

II.—RESULTS OF EXPERIMENTS: BY PROFESSOR J. E. DENTON.

The objects of the experiments undertaken were to determine the relative economy of the *Bergen*, as compared to the best type of paddle-wheel ferry-boat having the common style of overhead beam engine, a jet condenser, and drop-return flue boilers. The paddle boat selected for this purpose was the *Orange*, one of a pair of steel boats designed in 1887, by Mr. Francis B. Stevens, and representing the best modern example of its class of ferry-boats. The programme carried out was as follows:

1. The steam consumption, boiler evaporation, horse-power, and speed were determined for each boat during 14 hours of regular ferry service.

2. Each was run to Newburg and return, a distance of 120 miles, without stoppage, and the steam consumption per horse-power determined at the maximum capacity of the boilers. Also, the evaporative economy of the boilers, starting with new wood-fires, was determined during an interval of 14 hours, and the speed was measured by an estimate of the probable velocity of tides, and a log whose correction co-efficient was approximately known.

3. The speed of the *Bergen* was determined at the maximum horse-power for which the engines were designed, by opposite runs over a 1-mile course, after allowing the boiler pressure to accumulate above the average pressure which the boilers can maintain for more than a few minutes.

4. One of the screws of the *Bergen* was removed, and the power and speed determined by runs over a 2-mile course, first with the single screw pushing and then with it pulling the boat at equal speeds of revolution of the engine.

The principal conclusions drawn from the experiments are as follows:

1. The steam used per horse-power for all purposes is 25 lbs. per hour for the beam engine, and 22 lbs. for the triple engine, under their average conditions of ferry service; but the consumption of the *Bergen's* main engine is only 18.3 lbs. per hour per H.P., the direct-acting steam feed and circulating pumps, etc., consuming about 3.7 lbs. per indicated horse-power.

2. The steam consumption of both engines does not sensibly differ while in intermittent ferry service, from that found during continuous working of the engines.

3. The economy of the drop-return flue boiler of the *Orange* is practically the same as the locomotive type in the *Bergen*, both boilers evaporating on the average about 8½ lbs. of water per lb. of bituminous coal, under ordinary working conditions, thus making the consumption of coal per hour per H.P. about 2.9 for the beam engine, 2.6 lbs. for the *Bergen*, for all purposes, and 2.15 lbs. for main engines alone.

4. The speed of the boats under all conditions is practically in accordance with the law of cubes, and by the application of this law it appears that for a still-water speed of 12.6 statute miles an hour the following statements are practically true: The paddle-wheel boat would require 642 H.P., and would make 24½ revolutions per minute with a slip of 26 per cent.

The screw boat, using double screws, would require 680 H.P., an engine speed of 145 revolutions, and the slip would be 12½ per cent.

The screw boat, using one screw at the stern, would require 584 H.P., 152 revolutions per minute, and the slip would be 18 per cent.

The screw boat, using one screw at the bow, would require 692 H.P., 163 revolutions per minute, and the slip would be 18 per cent., but the recoil upon the hull of the water which the screw acts upon would make the apparent slip about 22 per cent.

5. The screw at the bow, using the same horse-power as the screw at the stern for equal revolutions, propels the boat slower than the screw at the stern by an amount practically equal to the equivalent of the extra resistance due to the increase of the velocity of the boat by an amount equal to the velocity of slip of the screw.

6. By calculations based upon the accepted relations between the slip of the screw and the velocity of a boat, it appears that, in order for the double screws to produce the same speed as a single screw of the same diameter at the stern, the slip of the latter must be to the former in the ratio of 18:11, and therefore the cause of the extra power consumed by the two screws, as compared with the one screw, is the fact that the slips are as 18:12.6, instead of 18:11. To alter this ratio of slip, the diameter of the two screws must be greater than that of the one screw.

A TRIPLE-EXPANSION MARINE ENGINE.

THE accompanying illustrations (from the *Steamship*) show a triple-expansion engine built for the steamship *Ivy* by the firm of Westgarth, English & Company, of Middlesboro, England, which is of a neat and compact type. Fig. 1 is a front view and fig. 2 a rear view of the engine showing its general construction; figs. 3, 4, and 5 show the details of the cylinders and valves.

The engine is of the ordinary inverted type, with three cranks, each cylinder having a separate direct-acting valve-gear. The condenser forms a part of the main framing, the back columns being cast upon it. These columns are of cast-iron, and fitted with separate slide-bars of cast-iron for the cross-heads. The after column is used as an exhaust pipe for the steam from the low-pressure cylinder, and the intermediate column contains the air-vessels for the pumps. The front portion of the frame consists of three circular cast-iron columns, the center one carrying the reversing-gear. The bed-plate is a strong box casting, to which the condenser and the columns are bolted. It carries five main bearings fitted with adjustable cast-iron bushes lined with white metal for carrying the shaft. It is secured to the engine-seat and the ship's frame with heavy bolts.

The cylinders are 16½ in., 26 in., and 44 in. in diameter and 33 in. stroke. The high-pressure cylinder has a piston valve, the intermediate cylinder an ordinary slide-valve, and the low-pressure cylinder an ordinary single-ported valve. The valve-gear is a link motion with double-bar link. The eccentrics are of cast-iron, with cast steel straps. The reversing-gear is worked by hand. The ordinary working pressure carried is 160 lbs.

The pistons of the high-pressure and intermediate cylinders are fitted with packing rings and springs of the Buckley pattern; that of the low-pressure with ordinary metallic rings. The piston-rods are 4 in. in diameter and the connecting-rods are 6 ft. in length between centers.

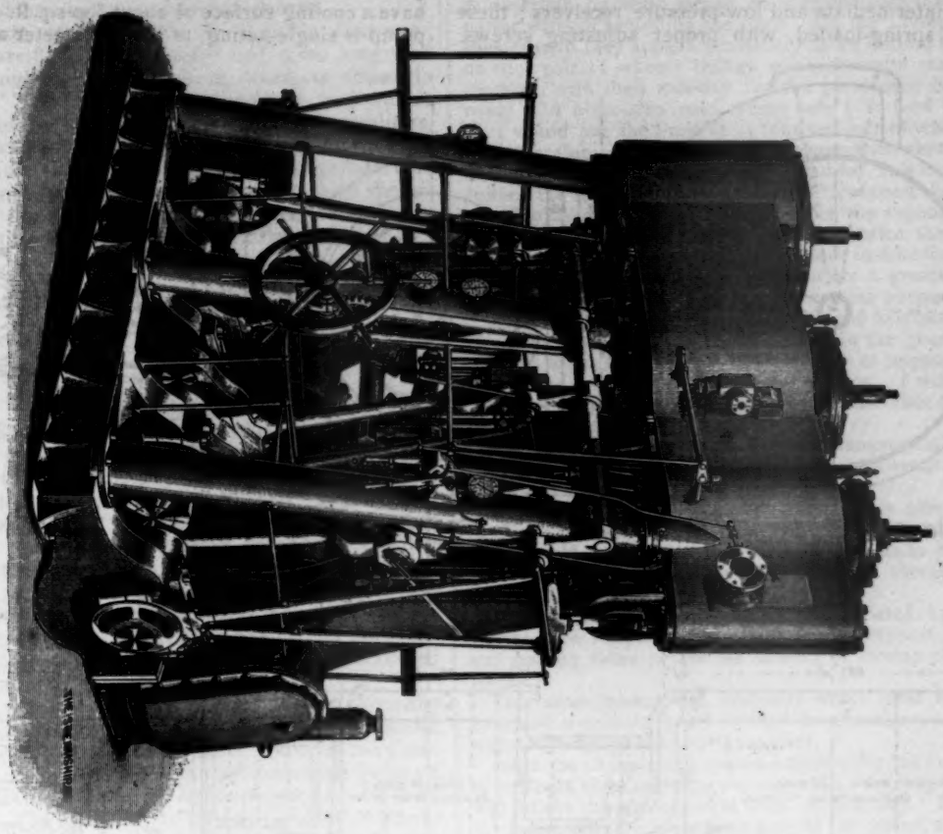


Fig. 1.

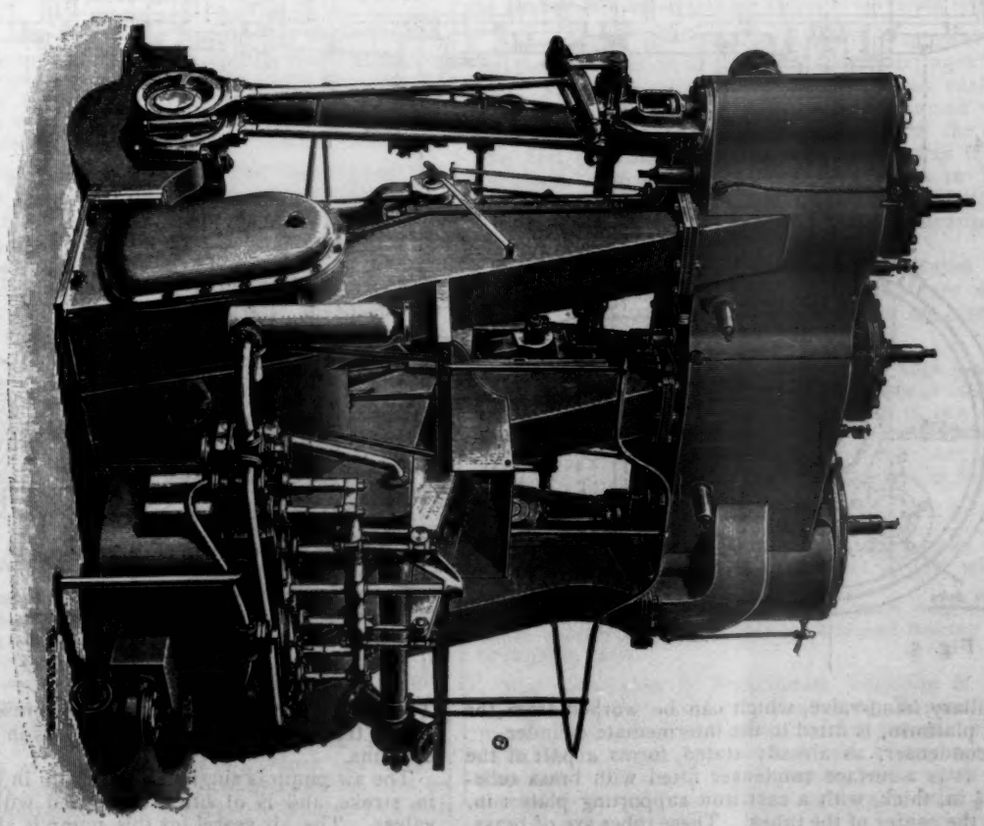


Fig. 2.

TRIPLE-EXPANSION MARINE ENGINE, STEAMSHIP "IVY."

Escape valves are fitted to both ends of each cylinder and to the intermediate and low-pressure receivers; these valves are spring-loaded, with proper adjusting screws.

⅜ in. outside diameter, packed with wood ferrules, and have a cooling surface of about 800 sq. ft. The circulating pump is single-acting, 11 in. in diameter and 18 in. stroke.

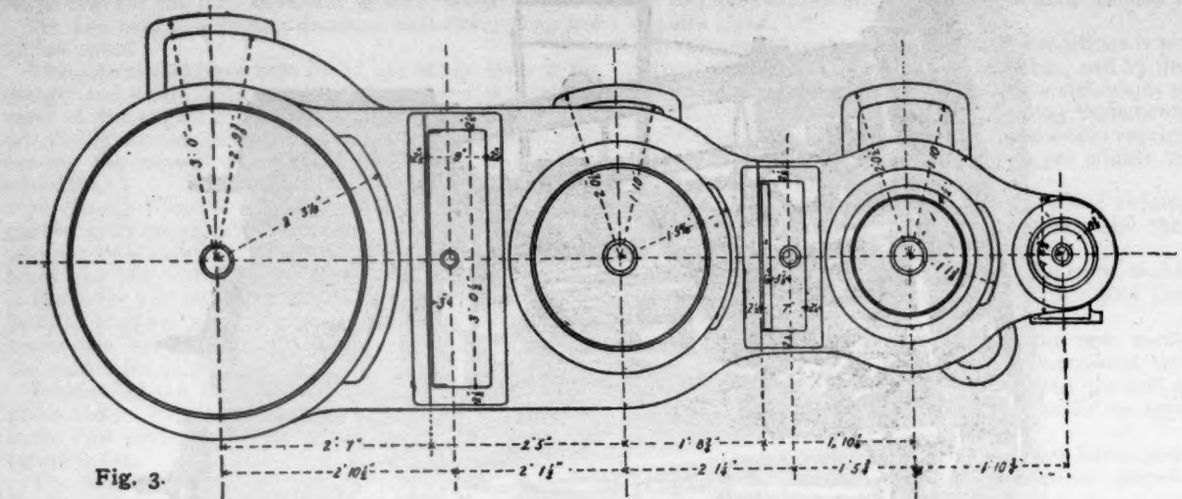


Fig. 3.

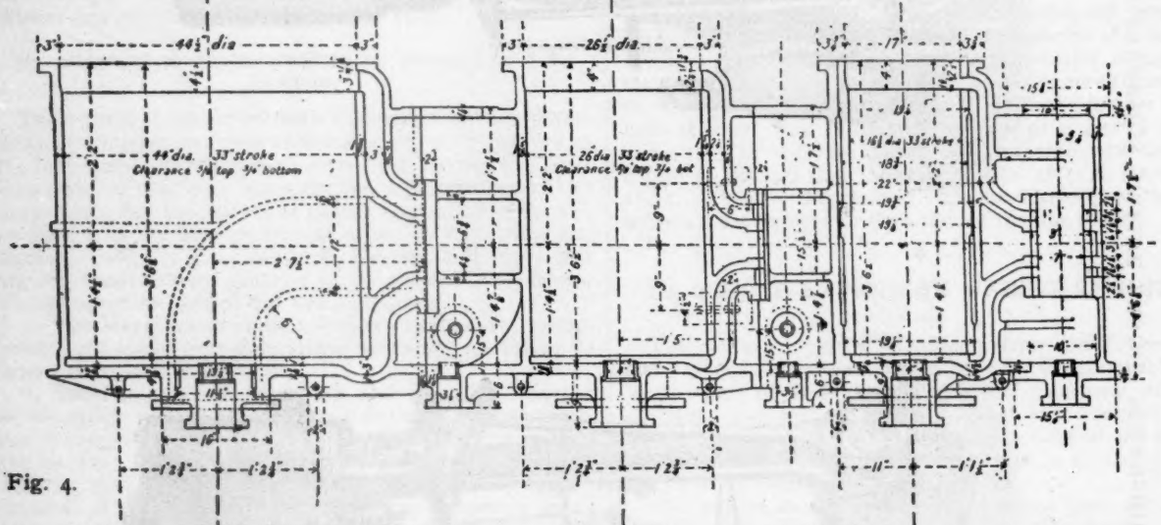


Fig. 4.

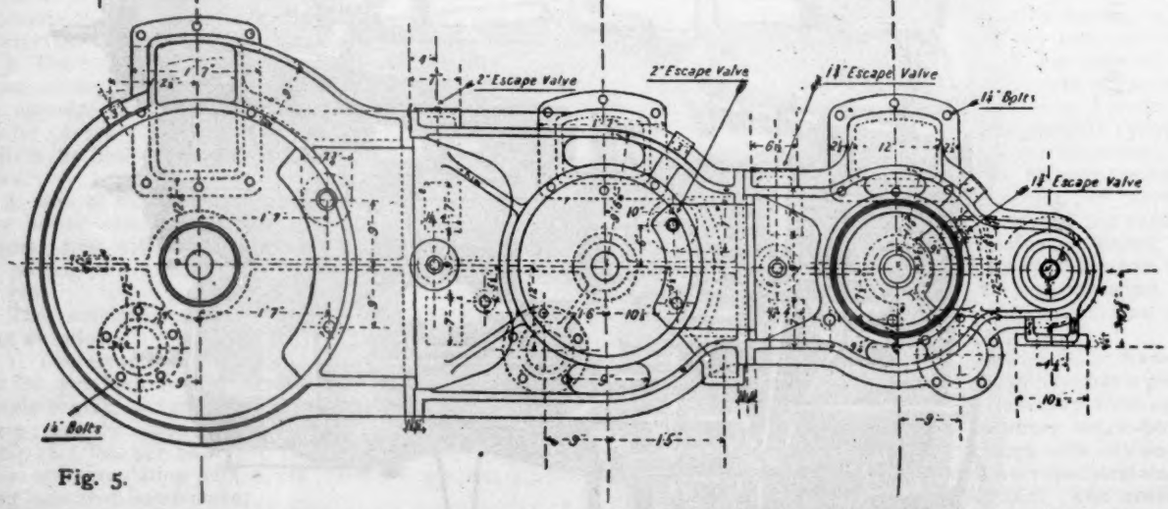


Fig. 5.

An auxiliary hand-valve, which can be worked from the starting platform, is fitted to the intermediate cylinder.

The condenser, as already stated, forms a part of the frame. It is a surface condenser fitted with brass tube-plates 1¼ in. thick, with a cast-iron supporting plate 1 in. thick in the center of the tubes. These tubes are of brass, The barrel, bucket, and valves are of brass. The air-vessel for this pump, as already stated, is in one of the back columns.

The air pump is single-acting, 13 in. in diameter and 18 in. stroke, and is of brass and fitted with the necessary valves. The air vessel for this pump is also contained in

one of the back columns. There are two single-acting feed pumps, 2 in. in diameter and 18 in. stroke, and also the necessary donkey, ballast, and bilge pumps.

The crank-shaft, of forged iron, is 8½ in. in diameter; the crank-pins are 8½ in. in diameter and 9 in. long, and are set at an angle of 120° with each other, as shown in the engraving. The propeller shaft is 8½ in. in diameter and connected to the crank-shaft by the usual couplings. The engine works a four-bladed screw of the usual pattern. Figs. 1 and 2 show very well the general arrangement and pattern of the engines, while figs. 3, 4, and 5 show the arrangement and dimensions of the cylinders and valves so well that no further description seems to be needed.

HORATIO ALLEN.

(*Continued from page* 86.)

In September of 1829 Mr. Allen became the Chief Engineer of the South Carolina Railroad. On his recommendation the gauge of the road was made 5 ft. Later the question of the gauge of the Erie road was referred to him as Consulting Engineer of that line. He advised that it also be made 5 ft. It was a great misfortune that his advice was not followed in both cases, and that the gauge for all American railroads was not made 5 ft. The extra width of 3½ in. would now be an immense advantage in the construction of both cars and locomotives. As the weight, size and capacity of these has grown the value of this 3½ in. of space between the rails has increased in about the same ratio.

At that early date the South Carolina Railroad Company had to decide whether the motive power of the road should be horses or locomotives. In a report made to the Company in November, 1829, Mr. Allen presented an estimate of the cost of transportation by horse-power and by locomotive power. The estimate of cost of locomotive power was based on facts obtained on the Stockton & Darlington Railroad. In his pamphlet, "The Railroad Era," Mr. Allen said:

> The result of that comparison was in favor of locomotive power, and the report contained a decided recommendation that locomotive power should be the power to be used on the South Carolina Railroad. But the basis of that official act was not the simple estimate resting on the facts as they existed on the Stockton & Darlington Railroad, but, as was stated in the report, was on the broad ground that in the future there was no reason to expect any material improvement in the breed of horses, while in my judgment the man was not living who knew what the breed of locomotives was to place at command.

This report was submitted to a full meeting of the Board, and the decision was unanimous to adopt locomotives as the tractive power on the road, and Mr. Allen added, "it was the first action of this kind by any corporate body in the world."

The South Carolina Railroad when first constructed consisted of timber rails or stringers 6 × 12 in., on which iron bars 2½ × ½ in. were spiked. When the question of motive power came up for consideration it was essential that the weight per wheel should not be greater than the structure described could safely bear. The load per wheel, therefore, had to be limited, and it also seemed to be highly important to place as great a quantity of power within one machine as possible. In another communication made May 16, 1831, to the President and Directors of the road Mr. Allen discussed the general subject of steam transportation, and especially the subject of boiler capacity of locomotives, and then said:

> When we come to consider the application of locomotives to wooden roads there are circumstances which call for attention, and a particular adaptation of arrangement to them. As the same amount of attendance and repairs attend engines of the various powers within the range that can be employed on railroads, it becomes a highly important object to place as great a quantity of power within one machine as possible. And this is more peculiarly the case on a road where the great and most difficult sources of expense are the attendance and repairs, while the fuel is comparatively of little consequence. As on every road there exists a limit of weight to be placed on each pair of wheels, and as on wooden roads this limit is much less than on an iron one, it becomes a still more interesting inquiry to ascertain by what means we may increase the quantity of power without exceeding the limit. On the Liverpool & Manchester road they appear practically to be limited to three tons on each pair of wheels, though some accounts state this to be too high, with their velocity, for the permanent benefit of the road. On a wooden road, where only ½-in. iron is made use of, I would put the limit at 1½ tons per pair of wheels.
>
> If, therefore, there can be no arrangements whereby this disadvantageous relation may be provided for, it is evident that to convey the same quantity of goods or transport the same number of passengers, we must incur twice the expense of attendance, twice the amount of repair, and twice the liability to accident. In fact, more than twice, since in doubling the weight of the engine we are able to appropriate a greater proportion of the increased weight to steam-generating purposes.
>
> The arrangement which I would propose to effect so desirable an object would be, as the limit exists in the quantity on each point of support, to increase the number of supports, and thus distribute the weight over a greater surface. I would therefore place the engine on six or eight wheels, and limit the weight to 1½ tons to each pair.
>
> There arise two objections to this arrangement, from the inequalities in the line of support; the one vertical, the other horizontal.
>
> If three or four wheels were united on a side to the same rigid straight line, and the road had irregularities in its surface, there would arise great and injurious strains to the structure, from the wheels not being able to adapt themselves to the irregularities.
>
> This difficulty may be completely obviated by giving the weight to be supported but two points of support on each side, and making these points the centers of motion of the pairs of wheels.
>
> This arrangement will evidently adapt itself with as much ease and simplicity to all vertical irregularities, as is the case with two wagons connected together.
>
> As to the change of direction horizontally, as in the entrance of turnouts and the passage of curves, a very simple adjustment will relieve the arrangement from all difficulty. If we connect the frame with the cross-piece only at the center, and by a horizontal point, the two sets of wheels will thereby be enabled to pass all curvatures with the facility of two simple wagons connected in the ordinary manner.
>
> No attempt has yet been made to accommodate the locomotive carriage to the passage of curvatures, by providing the means of changing the parallelism of the axles, and giving them the relative inclination that the radius of curvature requires.

As a result of this communication the Company authorized the construction of several "steam carriages" on this plan. Mr. Allen accordingly left Charleston early in the summer of 1831 for the North, and contracted with the West Point Foundry for the construction of the engines. The first one built and put in operation was the *South Carolina*. She was received at Charleston in January, 1832, and was put in operation in February, 1832. Three others were also constructed and put in operation before the end of 1832.

On October 1, 1834, a patent was granted to Ross Winans, of Baltimore, for eight-wheeled cars with two trucks. In his specification he described his invention as follows:

> I construct two bearing carriages, each with four wheels, which are to sustain the body of the passenger or other car, by placing one of them at or near each end of it, in a way to be presently described. The two wheels on either side of these carriages are to be placed very near to each other; the spaces between their flanches need be no greater than is necessary to prevent their contact with each other.
>
> * * * * * * * *
>
> The body of the passenger, or other car, I make of double the ordinary length of those which run on four wheels, and capable of carrying double their load.
>
> This body I place so as to rest its whole weight upon two upper bolsters of the two before-mentioned bearing carriages or running gear.

The Newcastle & Frenchtown Turnpike & Railroad Company built or used cars containing Winans' improvements, but denied the validity of his patent. Hence, in 1838, Winans brought his first suit at law against that Company. This was the beginning of 20 years of litigation with the railroads of the country, a brief history of

which was written by Mr. William Whiting, of Boston, counsel for some of the defendants, and published in 1860 with the title "Twenty Years' War against the Railroads." Of this litigation Mr. Whiting said:

It was at one time a question of millions, to be assured by a verdict of a jury—not indeed in a single suit, but as the result of enforcing the plaintiff's claim wherever railroads were in use and the courts of the United States had jurisdiction. A single verdict, sustained by the court, would enable that result to be easily reached. Stimulated by such hopes and fears, the litigation has been conducted with a corresponding perseverance, labor and talent. From Maine to Maryland, through a period of 18 years, in various courts of law and equity, against a great number of railroad companies and against other defendants, before juries of the country and juries of the city, before not less than six different judges of the courts of the United States, and with all the talent and learning that abundant means and a liberal hand could supply, with a pertinacity of purpose rarely equalled, the plaintiff has pressed his claims.

The case was finally carried to the Supreme Court in Washington and was heard in 1858, and a final decision was given in favor of the railroads and against Winans. In closing his account of this remarkable trial Mr. Whiting said:

Thus, after *twenty years* of controversy—the commencement of a large number of actions at law and in equity against the railroads, the actual trial of eight cases—the recovery, by Mr. Winans, of two verdicts sustaining his patent—the disagreement of the jury in three trials, the finding of one verdict at Canandaigua against him, the expenditure, on both sides, of not less than $200,000, and the authoritative settlement of the suit at Washington in favor of the railroads, ends this remarkable chapter in the history of litigation.

In these trials the testimony of Mr. Allen, and the eight-wheeled engines which he built in 1831, became very important evidence, and in an opinion given by Judge Nelson he said: "The decided preponderance of the evidence is, that this steam carriage embraces all the elements, arrangements, and organization to be found in the cars manufactured by the defendant."

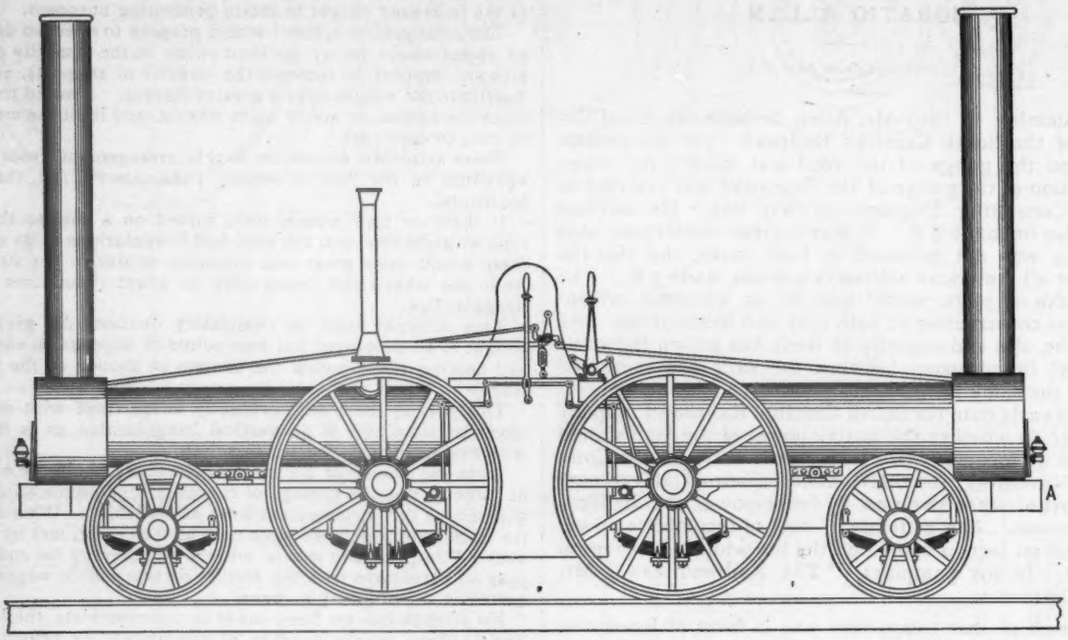


Fig. 2.

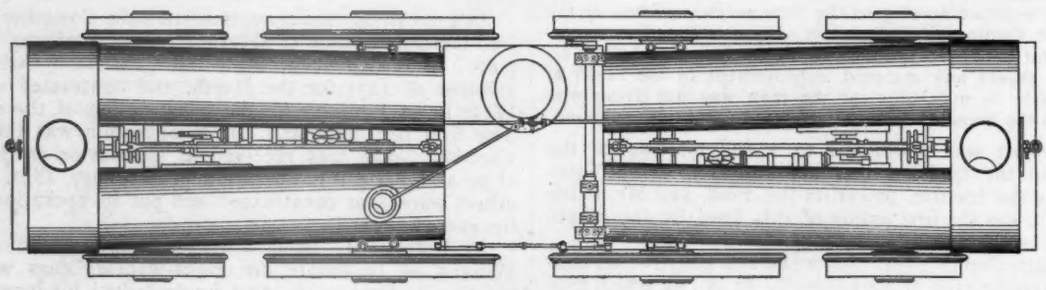


Fig. 3.

DOUBLE-TRUCK LOCOMOTIVE.

DESIGNED BY HORATIO ALLEN IN 1830, AND BUILT AT THE WEST POINT FOUNDRY, COLD SPRING, N. Y., IN 1831, FOR THE SOUTH CAROLINA RAILROAD.

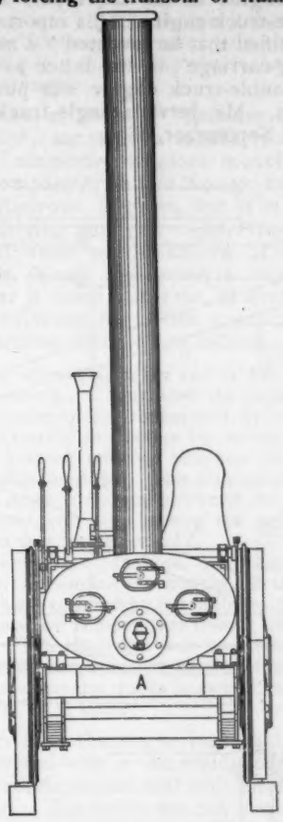
The invention or first use of the truck on locomotives has been a subject of dispute for a long time. This seems to be a proper occasion for summing up the evidence with reference thereto.

The use of a truck in connection with steam carriages is distinctly suggested in the English patent granted to William and Edward W. Chapman, dated December 30, 1812. In this it is said:

Fig. VIII. (not given here) shows a carriage of six wheels for the engine, which may rest equably, or nearly so, on each of its wheels, and move freely round the curves or past the angles of a railway. 1, 1, the fore pair of wheels, are, as usual on railways, fixed to the body of the carriage; 2, 2, and 3, 3, the other two pair, are fixed (on axles parallel to each other) to a

separate frame, over which the body of the carriage should be so poised, as that two-thirds of its weight should lie over the central point of the four wheels, where the pivot 4 is placed, and the remaining third over the axis 1, 1. The two-thirds weight of the carriage should rest on conical wheels or rollers, bearing upon the curved plates *c*, *c*, so as to admit the ledges of the wheels, or those of the way, to guide them on its curves or past its angles, by forcing the transom or frame to turn on the

Fig. 4.



pivot, and thus arrange the wheels to the course of the way, similarly to the carriage of a coal-wagon. And if the weight of the locomotive engine should require eight wheels, it is only requisite to substitute in place of the axis 1, 1, a transom, such as described (laying the weight equably upon both) and then similarly to two coal-wagons attached together, the whole four pair of wheels will arrange themselves to the curves of the railway.

There is no evidence to show that the Chapman plan was ever put into practice.

It was also brought out in the Winans litigation that in the early part of 1830, long timbers were carried on the Baltimore & Ohio Railroad on two four-wheeled cars, on which bolsters were placed, with a round pin passing down through a plate attached to the truck; string-pieces from 20 to 45 ft. long were then placed on the bolsters. Each of the two four-wheeled cars were thus enabled to adjust themselves to the vertical inequalities and horizontal curvature of the track. It was argued that this embodied substantially the principles of the double-truck car.

In the printed testimony in the Winans litigation Mr. Allen's and other concurring evidence is given at great length. Lithographed copies of the original plans and drawings of the double-truck engines designed by Mr. Allen, for the South Carolina Railroad, are appended to the volume of printed "Evidence for Respondents" in this case, and the engravings given herewith (figs. 2–5) are accurate copies made on a smaller scale from these lithographs. He testified that the plans for the eight-wheeled engines were drawn by C. E. Detmold, his assistant, in the close of 1830 or the early part of 1831.

Mr. Detmold testified as follows:

Before the drawings were commenced the principles of the eight-wheel double-trucks were fully developed and explained to me by Mr. Allen, so that I then clearly understood the subject of the construction and operation of the eight-wheel double-truck railroad cars, as well as I now do. The adoption of the eight-wheel engines became necessary from the fact that the Charleston Railroad was constructed of wooden rails with a light flat iron bar, the rails being supported on sleepers resting upon piles, at a distance of 6½ ft. apart. The four-wheel engines acted very injuriously upon this light structure, because the greater part of the weight of the locomotive was at one end, and therefore the slightest irregularity in the road caused the engine to operate like a heavy hammer upon the rails, which injured both rails and engine, and produced a very unsteady and unsafe motion. The object of Mr. Allen was to make such improvements in the running gear as to obviate these difficulties. This was done by placing two swiveling trucks under the long body of the engine. The body was very much longer than that of the ordinary four-wheel engine.

* * * * * * * *

The object was to obtain a small amount of pressure on each wheel, while the body carried was increased in length and weight, and to give the two trucks a proper action to conform to the curves and other inequalities of the road, and, at the same time, to cause the body of the steam carriage to run more smoothly or steadily on the road than the four-wheel steam carriages previously in use; and also to transport more freight and passengers, and run with more ease, safety, and economy, both as to the train and to the road.

Mr. Horatio Allen, in the winter of 1830 and 1831, made some of the drawings himself, and the drawing marked *G* (fig. 5), and signed by me, is one of the drawings showing parts of the steam carriage.

Mr. Detmold testified further that:

"During the winter of 1830 and 1831, under the direction of Mr. Allen, I made and assisted Mr. Allen in making drawings of the double-truck steam carriages. A portion of the original drawings is now before me . . . and a copy thereof, which I believe to be correct, is annexed to the deposition of Horatio Allen, in the present case."* He emphasized his evidence to another interrogatory by answering: "I am absolutely certain as to the date at which I assisted in making said drawings."

As already related the first of the engines was built from these drawings in 1831, and was put in operation in January, 1832.

The same volume of testimony from which such liberal quotations have already been made contains that of the late John B. Jervis, who claimed to have invented the locomotive truck, in which he says:

My attention has been particularly directed to the subject of the arrangement of the wheels of locomotives and cars to facilitate the running of locomotives and cars on curves; my attention was very early directed to that subject. It was a subject on which I had often thought a good deal, but made no experiments *until* 1831. In 1831 and early in 1832 I was very much engaged in devising some means by which four wheels could be substituted for two as the leading wheels of the locomotive, and finally prepared a plan by which the forward end of a locomotive was supported by a sort of independent carriage consisting of four wheels. Those wheels were placed near to each other and working under the main frame of the engine, which rested mainly on the outside timber on friction rollers, supported in its lateral position on the frame of the independent carriage by a center pin, and this independent carriage being a substitute for the two wheels formerly used. . . . A locomotive was made on that plan under my direction by the West Point Foundry Association in 1832. I think it was called the *Experiment*. The locomotive was put on the Mohawk & Hudson Railroad in the autumn of 1832.

In another deposition Mr. Jervis said:

I invented a new plan of frame, with a bearing carriage, for a locomotive engine, *in the latter part of the year* 1831, for the use of the Mohawk & Hudson Railroad, which was constructed and put on the road in the season of 1832.

* * * * * * * *

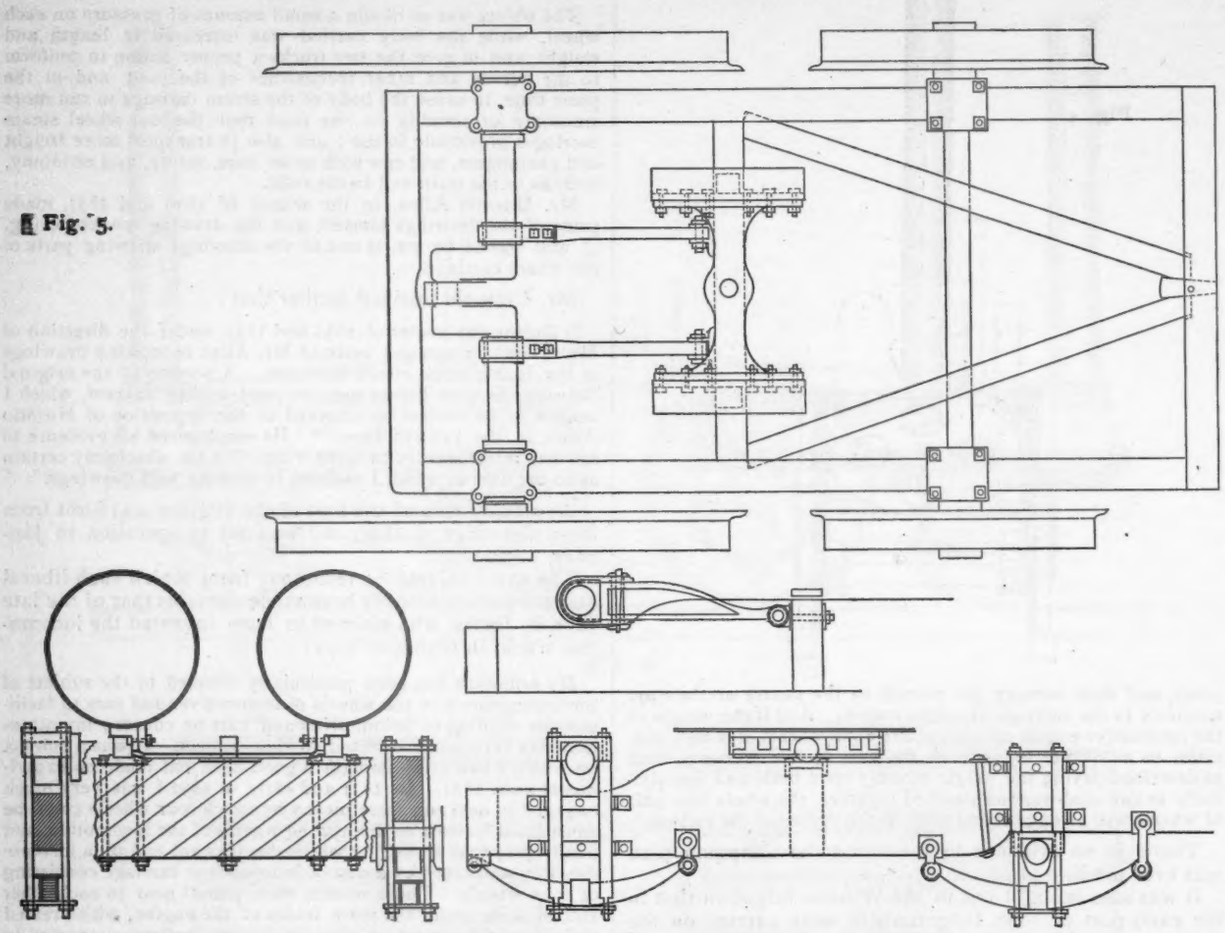
The engine had six wheels; on one pair, the driving-wheels, rested in the usual way, one end of the frame of the engine; the other end of the engine rested on the frame of a four-wheel car or truck, so arranged that by means of a center pin passing through a transom beam, the upper frame on which the engine rested could follow the guide of the lower frame, without necessarily being parallel with it. Friction rollers were placed on the lower or truck-frame, to support the engine-frame, and allow the truck-frame to move freely under it. By this means a long frame for an engine could be and is supported near its

* The engravings, figs. 2–5, have been made from copies of these drawings.

end, which provides for the most steady motion of the machine, and by the separate truck to guide, it passes on curves with all the facility of a short-geared car.

From the evidence quoted it will be seen that the drawings for Mr. Allen's double-truck engine were made during the latter part of 1830 and the beginning of 1831. In his report to the President and Directors of the South Carolina Railroad Company, dated May 16, 1831, he says: "I would therefore place the engine on *six* or eight wheels." As his report contemplated and advised the use of the truck, and as a two-wheeled truck was not known at that time, obviously what must have been intended was the arrangement of a four-wheeled truck at one end of the engine, and a pair of driving wheels attached to the main frame at the other.

Fig. 5.



DETAILS OF DOUBLE-TRUCK LOCOMOTIVE.

DESIGNED BY HORATIO ALLEN IN 1830.

In testifying in the Winans case the following questions were asked and the answers were given by Mr. Allen:

Q. You say that you became satisfied that it would be necessary to place the steam carriages on six or eight wheels, and that you devised the means of adapting the carriage for six or eight wheels; will you state what adaptation was made for six wheels?

A. By using one truck with four wheels, as already described in the eight-wheel arrangement, and connecting the other pair of wheels and their axle with the main frame of the locomotive.

Q. Did you construct a locomotive, or more than one, to be used on said road, with six wheels?

A. I altered one four-wheel English engine to a six-wheel arrangement.

Q. When?

A. I don't know.

Q. Try and recollect the year.

A. I can't recollect; I can make an inference about the time it must have been.

Q. How long was the six-wheel engine used, as near as you can recollect?

A. My recollection is, that it was in use until I left the road; I have no definite knowledge about it.

This testimony was given in 1853.

It is thus clear that Mr. Allen matured his plans for a double-truck engine in the latter part of 1830, and suggested a single-truck engine in his report of May 16, 1831. Mr. Jervis testified that he invented "a new plan of frame with a bearing carriage" in the latter part of 1831. Mr. Allen's first double-truck engine was put in operation in February, 1832. Mr. Jervis's single-truck engine was put in use early in September, 1832.

Mr. Jervis before his death wrote a letter in which he claimed that the plan of applying a truck to a locomotive which he introduced is the one which has since been universally used, whereas that which was devised by Mr. Allen, and adopted in the construction of the engines for the South Carolina Railroad was impracticable, and until the plan was revived by Mr. Fairlie it had fallen into entire disuse. While this is true, nevertheless the records show that, so far as priority of use is concerned, that to Mr. Allen belongs the credit of having first applied the truck to locomotives, and of having suggested its use as it was afterward applied by Mr. Jervis. Whether the alterations to the English locomotive, which Mr. Allen testified under oath he had changed to a six-wheeled engine, with a truck, were made before or after Mr. Jervis had the *Experiment* built, will now probably never be known.

In this connection it may be well to examine another bit of testimony bearing upon this question of the invention of the truck. In a paper by Mr. Vernon Smith, on "The Development of the Locomotive," read before the Canadian Society of Civil Engineers, in 1889, he says:

As the invention of the truck is claimed almost universally for America, and as it has subsequently become a prominent feature in American locomotives, it may be well to place on record a few facts that at least go to prove that the Newcastle shops had something to do with the invention.

Then, in referring to the old drawings in Stephenson's office in Newcastle, the Author says :

The next number, still 1831, is No. 42, ordered by the Saratoga & Schenectady Railway, an engine with 9 in. × 14 in. cylinders, one pair of 4 ft. 5 in. driving-wheels, and a truck with 4 wheels 2 ft. 8 in. diameter.

The third edition of Wood's "Treatise on Railroads," published in 1838, contains a tabular statement of the Dimensions of Locomotive Engines manufactured by R. Stephenson & Company. In this No. 42, for the Saratoga & Schenectady Railroad, is given, but it is distinctly said that it had two driving and *two supporting wheels*. As the two-wheeled truck was unknown at that time, obviously either Mr. Wood, who wrote in 1838, or Mr. Vernon, whose paper is dated last year, is wrong.

In giving his evidence Mr. Allen described the engines for the South Carolina Railroad as follows :

I gave each four wheels, at either end of the engine, an independent frame or truck. I connected the center of that frame or truck with the boiler of the locomotive by a center pin, and I supported each end of the boiler by rollers, resting on the sides of the truck about midway between the pair of wheels commonly called side-bearings. This arrangement allowed each truck or frame to move horizontally around the pin and allowed each frame to move vertically around the point at which the boiler rested upon that frame or truck.

Four of the wheels were 5 ft. high, and four, I think, were 3 ft. ; the cylinder of the engine was attached to the boilers. The frames or trucks were covered by the boilers ; by frame I mean the truck ; there was no independent frame ; the boilers constituted the frame. The draw-bar was connected to the truck. The connecting-rod was attached to the crank on main axle, with ball-joints, to allow the trucks to swivel and conform to the curves of the road.

It will be seen from the engravings that the fire-box of the engine illustrated was in the middle of the boiler, and that it had two barrels at each end which extended each way from the fire-box. The tubes are not shown in the cross-section which forms part of fig. 5. That they were multitubular boilers is known by the fact that Mr. Allen informed the writer that the steam-blast was not used on the engines, and that consequently the lamp-black from the resinous pine-wood which was used for fuel filled up the tubes. The fact that the steam-blast was not used also accounts for the high chimney shown in the engravings. The difference in the height indicated in figs. 2 and 4 is due probably to the arrangement of the original drawings on the sheet of paper, which did not leave room enough for the upper part of the chimneys of fig. 2.

There was one cylinder only to each truck. The cylinders were attached to the smoke-box and not to the truck frame. This made the ball-joint (which is not shown in the drawings) necessary to enable the truck to swivel in relation to the boiler and cylinders. If each crank happened to stop on a dead-center the engines were hard to start, and it was said that a judicious use of a fence-rail was sometimes required when this occurred.

In giving his testimony, Mr. Detmold said, of the working of these engines :

So far as the running gear was concerned, they all answered admirably the purposes for which they were built, and had the advantages over the former four-wheel engines, of distributing the weight of the locomotive over a larger surface of rails, and over more points of support, and by the double swiveling-trucks, that of conforming to all the irregularities and curvatures of the roads, and of far greater evenness and steadiness of motion, when running at high speed, and saving injury to the rails and engines by avoiding the hammering I have mentioned. After they had been running some years the difficulty of making sufficient steam became such, that the engines were superseded, but not owing to any defect in the running gear.

The drawings of these engines were obviously imperfect in many respects, but they are all that is left as a record of the construction of these remarkable machines. They show how, at that early date, Mr. Allen anticipated what have since been recognized as essential principles in the construction of locomotives and the operation of railroads. These are, 1st vertical, and 2d lateral flexibility of wheel-base, and 3d the distribution of weight of the locomotive on more points and over a greater surface of the road than was possible with the engines in use previous to 1830. These results, it will be observed, are a consequence of the adoption of the swiveling-truck in locomotive construction, which was devised by Mr. Allen in 1830, and which he constructed in 1831 and put in practice in 1832.

Furthermore, as Judge Nelson remarked in giving an opinion in the Winans case, these engines "embraced all the elements, arrangements and organization to be found in cars with two four-wheeled trucks." It was the early adoption of swiveling-trucks for both locomotives and cars in this country which has so materially "differentiated" American railroad practice from that in other countries, and to Mr. Allen belongs the credit of having had the prescience to see, and the courage to put in practice, what are now recognized as essential principles in railroad construction. With the light and experience of 60 years to guide us, it is now easy to see how very close these early engines of Mr. Allen came to being a most brilliant success. If the driving-axles had been attached to frames fastened to the fire-box, and if the two pairs of small wheels only had been connected to the truck-frames, and the cranks had then been placed at right angles to each other, and the driving-wheels coupled together, the engines would have achieved immortality.

(TO BE CONTINUED.)

RADIAL VALVE GEARS.

(Paper read before the Hull Institute of Engineers and Naval Architects, by J. R. Smith, Engineer.)

(*Concluded from page 62.*)

KIRK'S gear, fitted in the steamship *Australasian* and other ocean steamers, Patent No. 4,135, of 1882, and two of Bryce Douglas's gears, Patent No. 4,958, of 1884, are

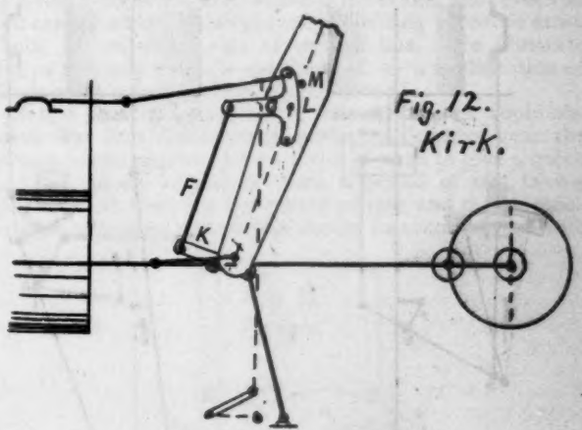


Fig. 12.
Kirk.

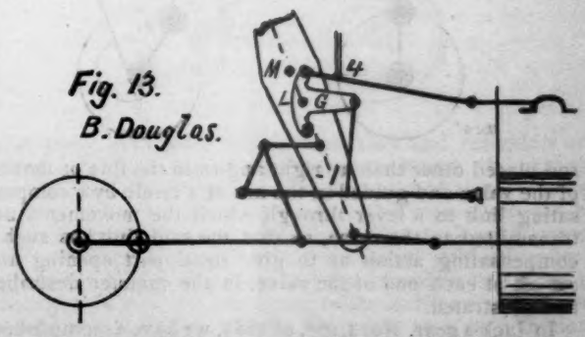


Fig. 13.
B. Douglas.

modifications of the same principle, but have the motion of the bell-crank link wrought off the connecting-rod in three different methods in the three gears.

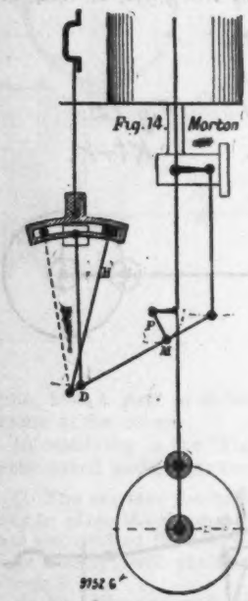
Fig. 12 shows Kirk's and fig. 13 shows one of Bryce Douglas's gear. In Kirk's gear we have the first introduction of the ingenious method of getting the motion of the valves lap + lead from the piston-rod crosshead through the oscillation of the bell-crank center *L*, this being placed a proportionate distance from the air-pump lever center *M*, thus producing when in neutral gear a motion of the valve equal to lap + lead from the crosshead, as in the Walschaert gear, the port opening being obtained from the vibration of the bell-crank link *G*, which wrought off the connecting-rod by rod *F* connected to compensating link *K*, which, with the previous examples of Brown and Joy, and of Morton's, yet to be brought before you, is the fourth style of correcting the error due to working off connecting-rod.

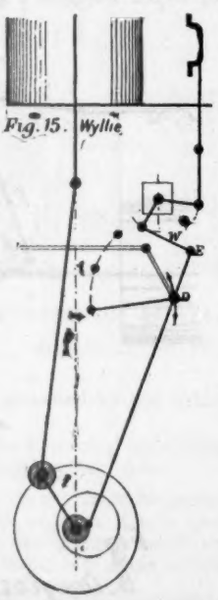
Kirk claims: "The combination of parts forming an improved valve motion, the essential feature of which is the imparting of motion derived from the connecting-rod through a compensating lever and radius-rod so as to lock a curved link centered on a pin, having a motion derived from the piston-rod, substantially as hereinbefore described."

Bryce Douglas claims: "In combination with the lever *I* worked by the piston-rod, and the bell-crank pivoted on *I*; the system of toggle links and their connections, whereby a rocking motion is imparted to *A*, suitable for working slide valves."

In Wyllie's gear, No. 14,783, of 1884, you will see from fig. 15, and in the sliding-block gear (not illustrated), the same adaptation of Hackworth's gear, in both cases with the addition of a compensation-link *W*, introduced to bring the angular motion into a vertical motion at the valve-rod. This compensating link *W* is an essential feature in this gear, as it corrects the unequal travel of valve and does away with the double-port openings on one side. A great many steamers engined by Richardson, of Hartlepool, have been fitted with Wyllie's gear, one of which, the *Santiago* of Hull, has now been working for three years with good results.

Wyllie claims: "The combination of parts forming my improved valve motion, consisting of an eccentric with its



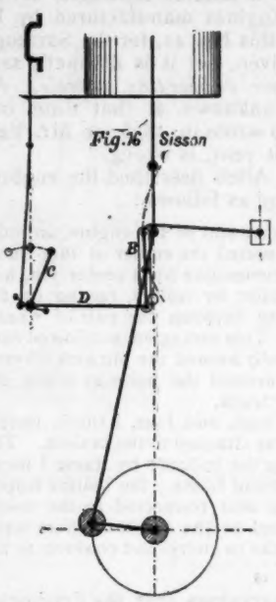


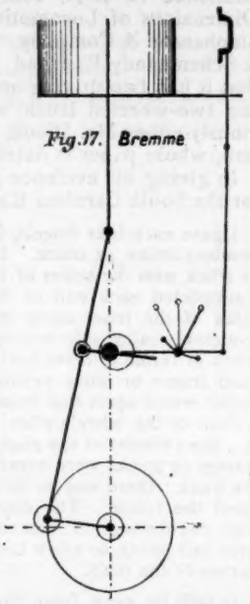
rod placed other than at right angles to the line of motion of the valve and guided in the arc of a circle by a compensating link to a lever through which the movements are transmitted to the valve, so that the said link has such a compensating action as to give equal port opening and cut-off at each end of the valve, in the manner described and illustrated."

In Jack's gear, No. 4,167, of 1885, we have accomplished, by the introduction of an extra swing-link, what Hackworth did by his slide-bars—viz., the fulcrum-pin *D* constrained to travel in a straight line. Fig. 19 is a diagram of the same, where it will be observed that fulcrum-pin *D* swings not only from point *C*, but also from point *J*, the neutralized action constraining *D* to move in a straight instead of a curved line.

It is strange that Jack has not applied it to a lever of the second order as well, as he only claims: "In the gear for operating the valves of motive-power engines, the mounting of the eccentric-rod upon a pin, at from one-third to one-fourth of the distance between the center of *H* and of the eccentric, the same being combined with a parallel motion constructed and operating as described."

Sisson, in 1885, in his Patent No. 6,254, brought out gear of the same class as Joy's, with the compensating





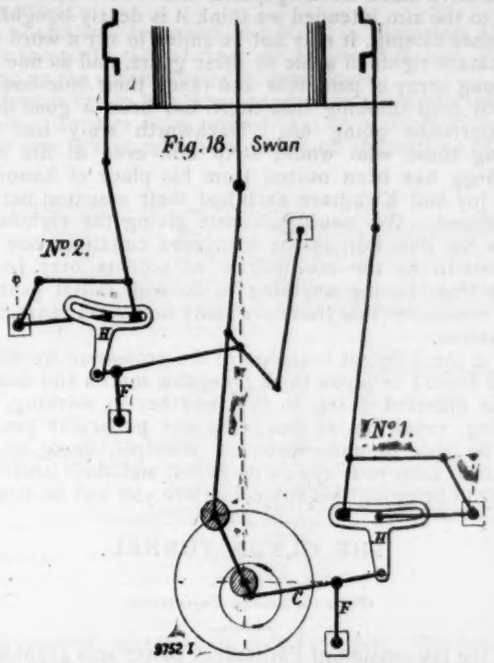
lever differently arranged. Fig. 16 illustrates one style which looks very much like Joy's gear, wrought by Kirk's connecting-rod motion, and so it is a very good gear; but there is not one new feature in the arrangement illustrated, which is a combination of the essential parts of Kirk's and Joy's gears. Sisson claims: "In the valve-gear of a steam-engine, the combination of a link *B*, pivoted to the connecting-rod of a radius-rod *C*, and of a lever *D* connected to the valve-rod of the engine, the lever being pivoted about a center movable to and fro along a path, the direction of which may be made variable," etc.

Fig. 18 shows two of the many arrangements of Swan gear, No. 6,254, of 1885. This is a modified and simplified Walschaert gear, when wrought by an eccentric—No. 1 side of illustration—and a modified and simplified Kirk's gear when wrought off connecting-rod—No. 2 side of illustration; inasmuch as in both of these gears the lap motion was wrought from piston-rod and the port opening was wrought off eccentric or connecting-rod. Now Swan accomplishes both of these motions by the one motion of his eccentric-rod, or the one motion of his vibrating lever. That this is so will be easily seen if we look at the No. 1 illustration, where you will see that the motion of eccentric-rod *C* swinging on a link *F* produces two motions, the first an oscillating motion of bell-crank link *H*, the second an up-and-down motion of the neutral center of this same bell-crank link. Now if we throw rod *E* into neutral position, we neutralize the first of these motions and only move the valve its lap + lead. The same applies to motion off connecting-rod, where it will be observed Swan has copied the essential part of Joy's patent compensating attachment to connecting-rod.

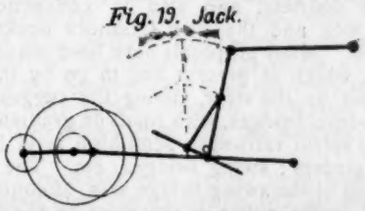
Swan claims: "The use of a reversing link carried freely upon a lever, both link and lever having their motions derived either from a single eccentric or from a single attachment to connecting-rod or single attachment to crank. The new construction of parts (none of which are new separately) worked from a single eccentric or connecting-rod or crank, substantially as described and illustrated."

According to date we should have mentioned Morton's gear (No. 149, of 1882) much earlier, but have reserved it

till now, as it introduces us to a distinct class in the manner in which expansion and reversion are accomplished. This gear, which has come much to the front of late, we illustrate in fig. 14, from which you will observe that when rod *H* is in line with valve-rod, and so gear is in neutral position, the valve will only move lap + lead, but by shifting top end of rod *H* along inverted quadrant *G*, we get the extra travel of valve required for port opening, and accord-



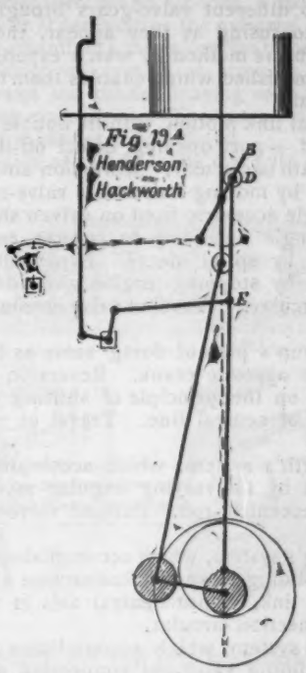
ing as rod *H* is on either side of quadrant center we have ahead or astern positions. This gear corrects more perfectly than Brown's or Joy's gears, the error arising from working off connecting-rod, previously mentioned. We referred to the important part *B* played in Brown's gear, also point *J* in Joy's gear, and so in this gear the point *M* plays the same important part, forming the basis of Morton's improvements. The radiating spanner *P* connects vibrating lever to connecting-rod and causes movable point *M* to follow an oval path whose major axis has become a segment of a circle, having a radius equal to the length of vibrating lever. While speaking on these essential points, lettered by the first letter of each patentee's name, we would say that in each of them, by shifting these special points, you can underdo or overdo the effects aimed at. For example, in fig. 7, if you shift *J* in Joy's gear nearer



or further from *R*, you give earlier or later steam top or bottom; the same points, therefore, in Brown's, Kirk's and Morton's have to be particularly watched in overhauling. While in Morton's gear the position of the end of the rod *H* in the quadrant is the means of expansion and reversion, all this is accomplished without either swing link or working sliding-block, so this gear combines all the good points of Joy's gear with the good points of the Walschaert gear, and gives an equal and regular steam distribution. It has been fitted in the Inman, Allan, Donaldson, Clan, City, and other ocean line steamers, giving the utmost satisfaction.

Fig. 19*a* shows Henderson's modification of Hackworth's gear inverted, and as fitted by D. & W. Henderson to some of their Anchor Line steamers, with very satisfactory results; the sliding-block works on two guide-bars, and wears remarkably well.

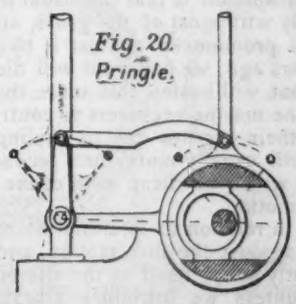
In No. 7,886, of 1886, Bremme took out a patent for working a shaft other than the crank-shaft by means of a novel connection to connecting-rod. This we illustrate in fig. 17, where you will see that the swivelling arm attached to connecting-rod causes the small eccentric shaft to make one revolution in one complete sweep of connecting-rod. I think I may say few practical engineers will adopt this



roundabout way of doing what Joy, Kirk, Morton, and others accomplished in a much simpler and more mechanical way.

Fig. 20 shows Pringle & Arrol's gear, which is wrought by a single eccentric fixed opposite the crank, and reversion and expansion are accomplished by shifting eccentric strap about 30° on either side of neutral line. We illustrate this as the only example we know of, of a modification of Englemann's gear, previously mentioned.

Before concluding our list of valve-gears, we would observe that in a theoretically perfect slide-valve gear the motion would require to be a series of jerks to give a quick and full steam admission, then a period of rest, then a quick cut-off, then another period of rest, and then a quick exhaust opening; and all this should be accomplished with



the same gear with which expansion and reversion are done. A cam-gear working separate steam and exhaust grid-valves can accomplish the first part of these requirements, and I would mention that this was attempted by Robertson, of Glasgow, who, about 1870, took out a patent for working separate steam and exhaust grid-valves by a groove in a revolving disk, and the complete revolution of this groove moved a projecting roller on the end of a lever, producing a motion exactly the same as a cam motion. The Allan mail steamer *Caspian* had her first surface-condenser engines fitted with this gear, which was reversed by a spiral sleeve. They were economical in coal, but the

noise and action of the valve-gear put you in mind of the shuttle-throw of a power loom.

The grid style of valve has been revived by Mr. Strong, of Philadelphia, who proposes to work the same by a modification of Brown's gear; he accomplishes the quick and slow movements of his grid-valves by an ingenious combination of levers.

In these 20 different valve-gears brought before you, mixed and confusing as they appear, there are certain peculiarities in the method by which expansion and reversion are accomplished which enables them to be classified. We will include

1. The usual link motion, with its double eccentric, giving lap + lead + port opening, direct off-throw of eccentric, whose path is circular. Reversion and expansion are accomplished by moving link across valve-rod.

2. The single eccentric fixed on driven shaft, but free to revolve the angle necessary to reverse engine, which is accomplished by spiral sleeve. Expansion can only be accomplished by stopping engine and adding to driving stop; path circular. Travel of valve constant at all grades of cut-off.

3. Englemann's plan of doing same as No. 2, but with fixed eccentric opposite crank. Reversion and expansion accomplished on the principle of shifting eccentric strap 30° each side of neutral line. Travel of valve constant; path circular.

4. Hackworth's system, which accomplishes expansion and reversion by the varying angular motion of the fulcrum end of eccentric-rod. Path of valve-rod connection elliptical.

5. Waldegg's system, which accomplishes expansion and reversion by sliding valve-rod connection across vibrating or bell-crank link, whose neutral axis is fixed. Path of valve-rod connection circular.

6. Morton's system, which accomplishes expansion and reversion by sliding valve-rod connection across inverted quadrant. Path of valve-rod connection elliptical.

We thus see that most of the radial gears fall under the fourth, fifth and sixth class. Each of these different classes, whether considered as steam distributors or as mechanical arrangements, have their merits as steam distributors; as this has been handled in a thoroughly scientific manner in two papers published in *Engineering*, September 17 and October 8, 1886, also in the interesting and able paper read by Mr. Milton before the North-East Coast Institution of Engineers & Shipbuilders, in both of which, by the aid of Zeuner's diagrams, the movements of the principal gears are analyzed, I commend these papers to your careful study. In looking at these different classes as mechanical arrangements, the first thing a practical engineer considers is the number of moving wearing parts, with the relative strains on same. Looked at only in this light, our own opinion is that the usual link motion compares favorably with most of the gears, and notwithstanding the doom pronounced against it by Sir W. Siemens some nine years ago, we believe it will die hard. If there is anything that will hasten this more than another, it is the desire of the marine engineers to contract the fore-and-aft length of their engines due to tripling same, and the saving here will usually more than recoup the extra cost and royalties, which handicap most of the gears compared with the link motion.

Considered in relation to fore-and-aft room there is one serious thing against the link motion, and that is, it does not conveniently adapt itself to the altered position of the valve-chests unless we introduce vibrating levers, and when these are added to the cost, then most of the other gears will compare favorably as to price, and accommodate themselves to most of your requirements.

Having said this much for the link motion, we think it fair to state that there are some of the gears which have been brought before you which will compete with it as regards cost and results. Taking this into account as well as the fact that these same gears are better steam distributors, let us complete the comparison, and examine them as regards up-keep. Take the case of Hackworth's gear, having a large eccentric and sliding bars, and which has more sliding surface than other radial gears, the testimony of those who have recently adopted this style is that they have less repairs and adjustment than with the link motion; the same is the case to a greater extent in Marshall's gear. These gears have five working parts, when engines are working, as compared with the direct link-motion's ten, while the Joy, the Walschaert and the Morton styles, having about the same number as the link motion, yet wear better. A number of the other gears noticed in this paper have more working parts, and where this is necessary to the aim intended we think it is dearly bought.

Before closing, it may not be amiss to say a word about the patent rights of some of these gears, and as one scans the long array of patentees and reads their blue-books we cannot help thinking that there has been a good deal of appropriation going on. Hackworth truly has fallen among some who would strip him even of his honor. Waldegg has been ousted from his place of honor, and both Joy and Kirk have each had their essential parts appropriated. We would advocate giving the rightful patentee his due, but, as the hampered condition one finds himself in by the multiplicity of patents may frighten some from having anything to do with radial gears, let such remember that there are some first-class gears free to the public.

If, in the different branches of the profession we fill, this paper should help you to so grasp the merits and demerits of the different gears, so that whether in working, overhauling, repairing or designing any particular gear you will be able to understand its principle, know its good qualities, keep your eye on its faults, and do it justice, my object in bringing this subject before you will be attained.

THE CLYDE TUNNEL.

(From the London *Engineering*.)

IN the last session of Parliament power was granted to a private company to construct a tunnel under the river Clyde, at Glasgow, to provide what has for many years been desired by the citizens—a means of taking vehicles across the river between the north and south divisions of the central part of industrial Glasgow. The contract for making the tunnel has now been let to Messrs. Hugh Kennedy & Sons, Partick, who have had considerable experience in such undertakings. They successfully completed a tunnel under the Forth & Clyde Canal several years ago in connection with a branch line of the North British Railway to Dumbartonshire, and they also constructed the greater part of the Greenock & Gourock Railway, in which there was a tunnel about 1½ miles long.

The river tunnel is to be situated at Finnieston, about the middle of the harbor, and a point most convenient for the traffic to the engineering works in the Anderston and Finnieston districts, and also in connection with the Queen's Dock and the New Cessnock docks now being constructed. Many proposals have been made for meeting the traffic, which at present has to go by the bridges, a mile further up the river, among the suggested schemes being high-level bridges, with roads on gradients, hydraulic hoists, and spiral railways; semi-high level bridges, with swinging girders; swing bridges, etc. The difficulty in the adoption of the swing bridge was, of course, the interruption of traffic either on the river or the bridge when open, while the high-level bridges were condemned because of the length of the approaches. The Clyde Trust is having built a ferry for passenger and vehicular traffic, with a deck which is raised or lowered to suit the rise and fall of tide.

The plan proposed by Messrs. Simpson & Wilson, C.E., Glasgow, and adopted by Parliament, has many points of advantage. Of the scheme we give on the present page several illustrations, which practically explain themselves.

With three tunnels the vehicular traffic going south will have a separate subterranean passage, and there will also be one for the traffic going north, while the central tunnel is for passengers only. There will be only 2 ft. between the tunnels. The diameter of the part of the tunnel under the river, built in cast-iron segments, will be 16 ft.; that under the quays, where there is boulder clay, will be built of brick arching, and be 18 ft. in diameter. At their high-

est points the tunnels are to be 15 ft. below the bed of the river, thus leaving ample room for future dredging operations, and 35 ft. and 46 ft. respectively below low and high-water levels. The shaft on the north side will be about 400 ft. west of Finnieston Street and 180 ft. from the quay wall, while the shaft on the south side adjoins the Govan Road, and is about 125 ft. from the quay wall. As the river is 415 ft. wide, the length of tunnel from shaft to shaft is 720 ft.

Both shafts will be round and 80 ft. in diameter. The shaft on the north side of the river will be 72 ft. 6 in. deep, and that on the south side 75 ft. 6 in. deep.

Operations are to be started at once on the south side of the river. Borings have proved that at a depth of 45 ft. boulder clay is met, which continues till the bottom of the shaft is reached, where again rock is found. The boulder clay will enable the contractor to start his tunneling northward with the surety that he will be free from water for a good distance. The shaft is to be formed of an outer and inner ring of cast-iron segments or plates measuring 4 ft. long by 2 ft., and of ½-in. metal with 3-in. flanges bolted together. The surface having been made perfectly level, the two rings forming the first segment will be placed in position, and the 4 ft. between the rings filled with concrete. To the bottom of the segment will be fitted a cutting edge of V section.

The excavation of the material occupying the space inside the segment will cause it, of its own weight, to sink, and segments will be added as the cylinder sinks down. When this cylinder reaches a depth of 27 ft., the bolting on of additional segments will be discontinued; but the cylinder will still be sunk until the boulder clay is reached —at a depth of 45 ft. From the top of the cylinder, when in its final position, to the surface level—18 ft.—the wall of the shaft is to be ordinary brickwork in cement, while the bottom part of the shaft is also to be walled with brick, as there the boulder clay does not require the cast-iron segments. At its final depth of 75 ft. the walls will have rock for their foundation, and the flooring will be of concrete.

The shaft on the south side having been completed in the manner described, the tunneling will be started in a northern direction. For a distance of at least 100 ft. the material is boulder clay, with the Mavisbank Quay on the surface. This part will be constructed on a concrete invert flooring, with circular brick lining 2 ft. thick (five rings), the diameter being 18 ft. The remaining part of the tunneling is of iron segments 1 in. thick, measuring 4 ft. long and 18 in. broad, with flanges 1¼ in. by 6 in. deep, strengthened by stiffeners 12 in. apart. Between the segments there is a space, ¾ in., for wedging up with soft wood, so as to make it water-tight. This system of wedging up iron segments has been largely adopted in the north of England, under great pressures, sometimes as much as 200 lbs. to the square inch. In the case of the Clyde Tunnel the pressure is not expected to be more than 25 lbs. to the square inch.

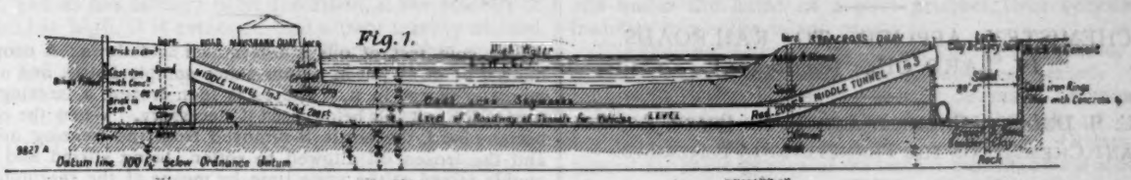
The method of procedure in constructing the tunnel under the river will be similar to that adopted by Mr. Greathead in connection with the Southwark Subway. In the case of the Clyde Tunnel a good start will be got from the 18-ft. brick tunnel already described. The boulder clay, it is thought, reaches to half-way across the River Clyde, and until the wet sand is met with no air pressure will be used. The work will proceed in 18-in. lengths. The contractor will probably manage to obviate the necessity of taking the material through an air-lock, a tedious process. For the first two or three lengths the material will be taken through the air-chamber; but after that the contractors will probably adopt the system of stowing the material along the insides of the tunnel, leaving only a center passage for working operations. The material can then be taken out after the tunnel is completed.

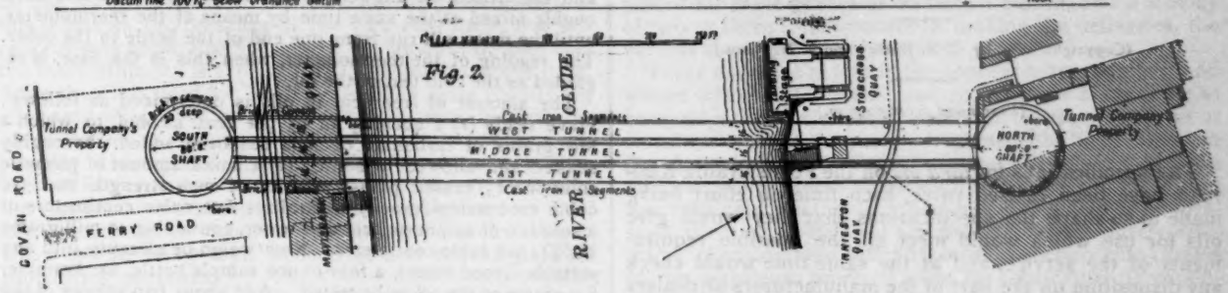
On the north side of the river the material is wholly wet sand, and, of course, the cast-iron segments will form the tunnel to the shaft.

The shaft on the Finnieston (the north) side of the river will be carried 80 ft. below the surface level. The process to be adopted will be similar to that in the case of the south shaft; but heavy pumping will be required to keep the material clear of water while the excavations are being made. Cast-iron segments similar in construction will be sunk the whole depth, but for 18 ft. above the segments the wall of the shaft will be formed of brickwork. The foundation of the shaft will be composed of concrete 8 ft. thick in the center and thinning to 4 ft. at the sides.

The segments on the inside of each shaft will have their flanges turned inward, except where the tunnels are intended to enter the shaft. At these points the flanges are turned outward in the case of the inner ring of the segments, so that the bolts will be exposed and the segments easily removed for the bolting of the tunnel to the side of the shaft. When this is being done a cast-iron round air-tight cover will be bolted over the place where the junction is to be made. This will allow the connection to be made under air-pressure, which is necessary, as the material is wet sand. The round cover can only be removed when the connection is finished and bolted.

The center tunnel, which is for passenger traffic only, is to be formed of iron segments from shaft to shaft. The gradients of 1 in 3 at the ends will have flat stairs, and from the landing, which will take up the inner half of each shaft, there will be stairs to the street level, thus obviating the necessity for hoists, against which there seems to be a prejudice in the public mind.





The outer half of each shaft is to be fitted with six hydraulic hoists for vehicles. The two center hoists are to take 10 tons each, and will be worked on the balanced principle. Of the other four lifts two will be capable of raising 7 tons each and the other two 5 tons each. These will be worked independently of each other. The hoists on one side will be used in connection with the tunnel for traffic going northward, and the other two for the southward traffic. In this way the possibilities of the hoist not being in position for use when required are reduced to a minimum.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.*

CHEMISTRY APPLIED TO RAILROADS.
IV. LARD OIL. (*Continued.*)

By C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad.

(Copyright, 1889, by C. B. Dudley and F. N. Pease.)

(*Continued from page 77.*)

THE specifications for *lard oil* on the Pennsylvania Railroad have been revised twice, each time an effort being made to so shape the specifications that they would give oils for use which would meet all the possible requirements of the service, and at the same time would check any disposition on the part of the manufacturers or dealers to sell an inferior article at the price of a good one. Following is a copy of the latest revision, which represents the specifications for lard oil now in use.

PENNSYLVANIA RAILROAD COMPANY.

Motive Power Department.

Specifications for Lard Oil.

Two grades of lard oil, known in market as "extra" and "extra No. 1," will be used, the former principally for burning and the latter as a lubricant.

The material desired under this specification is oil from the lard of corn-fed hogs, unmixed with other oils, and containing the least possible amount of free acid. Also from October 1 to May 1 it should show a cold test not higher than 40° Fahrenheit. Oil from lard of "mast," or distillery-fed hogs, does not give good results in service, and should never be sent. Also care should be taken to have the oil made from fresh lard. Old lard gives an oil that does not burn well, and also gums badly as a lubricant. The use of the so-called neat's-foot stock, either alone or as an admixture in making the "extra No. 1" grade, is not recommended. Neat's-foot oil is used by the Railroad Company when the price will admit, but it is preferred to have it unmixed.

Both grades of oil will be purchased on sample, and shipments must conform to sample. A four-ounce sample is sufficient, and should be sent as directed by the Purchasing Agent. The color of the sample has an influence in the placing of orders. Those lightest in color are regarded as best.

Shipments must be made as soon as possible after the order is placed. All shipments received at any shop after October 1 will be subjected to cold test and rejected if they fail, unless it can be shown that the shipment has been more than a week in transit.

Shipments of the "extra" grade will not be accepted, which

I. Contain admixtures of any other oils.

II. Contain more free acid than is neutralized by four cubic centimeters of alkali, as described below.

III. Show a cold test above 45° Fahrenheit from October 1 to May 1.

IV. Show coloration when tested with nitrate of silver, as described below.

Shipments of "extra No. 1" grade will not be accepted, which

I. Contain admixtures of any other oils.

II. Contain more free acid than is neutralized by 30 cubic centimeters of alkali, as described below.

III. Show a cold test above 45° Fahrenheit from October 1 to May 1.

The cold test of oils is determined as follows: A couple of ounces of oil is put in a four-ounce sample bottle, and a thermometer placed in it. The oil is then frozen, a freezing mixture of ice and salt being used if necessary. When the oil has become hard, the bottle is removed from the freezing mixture and the frozen oil allowed to soften, being stirred and thoroughly mixed at the same time by means of the thermometer, until the mass will run from one end of the bottle to the other. The reading of the thermometer, when this is the case, is regarded as the cold test of the oil.

The amount of free acid in oils is determined as follows: Have ready (1) a quantity of 95 per cent. alcohol, to which a few grains of carbonate of soda has been added, thoroughly shaken and allowed to settle; (2) a small amount of turmeric solution; (3) caustic potash solution of such strength that 31½ cubic centimeters exactly neutralizes five cubic centimeters of a solution of sulphuric acid and water, containing 49 milligrams H_2SO_4 per cubic centimeter. Now weigh or measure into any suitable closed vessel, a four-ounce sample bottle, for example, 8.9 grams of the oil to be tested. Add about two ounces of the alcohol, warm to about 150° Fahrenheit, add a few drops of the turmeric solution and shake thoroughly. The color becomes yellow. Then add from a burette graduated to cubic centimeters, the caustic potash solution, little at a time, with frequent shaking, until the color changes to red, which red color must remain permanent after the last vigorous shaking. The number of cubic centimeters used shows whether the oil stands test or not. In the case of the "extra" grade, if more than four are used, or in the "extra No. 1" grade more than thirty are used, the oil fails.

The nitrate of silver test is as follows: Have ready a solution of nitrate of silver in alcohol and ether, made on the following formula:

Nitrate of silver,	1 gram.
Alcohol,	200 grams.
Ether,	40 "

After the ingredients are mixed and dissolved, allow the solution to stand in the sun or in diffused light until it has become perfectly clear; it is then ready for use and should be kept in a dim place and tightly corked.

Into a 50-cubic centimeter test tube, put 10 cubic centimeters of the oil to be tested (which should have been previously filtered through washed filter paper) and five cubic centimeters of the above solution, shake thoroughly and heat in a vessel of boiling water 15 minutes with occasional shaking. Satisfactory oil shows no change of color under this test.

THEODORE N. ELY,
General Superintendent Motive Power.

Office of General Superintendent Motive Power, Altoona, Pa., March 19, 1889.

It will be observed that the specifications state, first, what kind of material is desired, and, second, what kind of material will be accepted. The material which will be accepted is not always the material that is desired, and this distinction is pervading all the more recent specifications issued by the railroad company. A want of care in reading the specifications by the manufacturers has frequently led them into serious difficulty. They have based their action on that part of the specifications which tells what is desired, not noticing, first, that the specifications always give certain limits either side of the material desired, and, second, forgetting that in commercial processes producing manufactured products usually the methods are not capable of giving results that are very close to what is aimed at. It is very much safer to take the limits

* The above is one of a series of articles by Dr. C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist of the Pennsylvania Railroad, who are in charge of the testing laboratory at Altoona. They will give summaries of original researches and of work done in testing materials in the laboratory referred to, and very complete specifications of the different kinds of material which are used on the road and which must be bought by the Company. These specifications have been prepared as the result of careful investigations, and will be given in full, with the reasons which have led to their adoption.

The articles will contain information which cannot be found elsewhere. No. I., in the JOURNAL for December, is on the Work of the Chemist on a Railroad; No. II., in the January number, is on Tallow, describing its impurities and adulterations, and their injurious effects on the machinery to which it is applied; No. III., in the February number, is on Lard Oil. These chapters will be followed by others on different kinds of railroad supplies. Managers, superintendents, purchasing agents and others will find these CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION of special value in indicating the true character of the materials they must use and buy.

which will be accepted, and then allow margin enough so that the product will never come below or above those limits. That part of the specifications which describes what is desired is regarded as representing what material in our experience will give the very best results in service, and the nearer manufacturers can get to this the better.

The reason for desiring material from corn-fed hogs, and for avoiding that from mast-fed or distillery-fed hogs, has already been explained, as well as the effect of admixtures of cotton-seed oil with the lard oil. It goes without saying also that admixture of cheaper oils with higher-priced oils is a fraud, and therefore specifications must guard against it. The requirements against free acid have a twofold reason. First, the amount of free acid in an oil is in many cases evidence of the stock used in making it, and as has already been described, if the amount of free acid is high, it is evidence that a poor quality of lard has been used in making the oil. There is also another reason for avoiding large amounts of free acid in lard oils. Free oleic acid apparently oxidizes readily on exposure to the air, and the more free acid there is in an oil the less satisfactory results are obtained from it, both as a burning oil and as a lubricant. We have not demonstrated that this is due to the presence of the free acid itself, but our experiments show that the larger the amount of free acid the more difficulty is experienced in maintaining the light, when the oil is used for burning, and the more readily the oil gums when used as a lubricant. It may be that the cause for this is the presence in the oil of other substances, possibly decomposed tissues, which are an accompaniment of larger amounts of free acid. Whatever the cause, the fact remains that the prime grade, if high in free acid, does not give good results as a burning oil, and the extra No. 1 grade being high in free acid is not as good for lubricating purposes.

The freshness of the lard used in making the oil is also an important element. Positive experiments made with a signal oil which had been kept five or six months showed that its burning qualities had deteriorated very greatly. The detail of this experiment is interesting. A sample of signal oil was made up in the usual way, the constituents being *extra lard oil* of excellent purity and quality, and the usual amount of petroleum product. A burning test was made with an ordinary hand lantern and a new wick. This oil showed on test, several times repeated, that a good flame could be maintained without trimming the wick for from 30 to 35 hours' continuous burning, care being taken to keep the pot supplied with oil. Some of this same oil was then put in a bottle and kept, being protected from dirt, but access of air allowed through the neck of the bottle, with occasional agitation of the oil. At the end of six months this oil had lost its burning qualities almost entirely. In no case could a lamp with a new wick and fresh trimming be kept lighted over seven or eight hours without going out. This experiment was repeated times enough to eliminate chance variables, and all our experience on the road confirms this view—namely, old signal oil does not burn satisfactorily. After these experiments were made, instructions were issued to the men that they should not order signal oil enough at any local point to last them longer than two months.

The same difficulty is experienced in a modified degree with oil made from old lard, and every year, especially during the months of June, July and August, the signal oil is less reliable than three months later, after the new killing and freshly-made lard begins to appear.

The paragraph in the specifications in regard to neat's-foot oil or neat's-foot stock is perhaps worthy of a moment's notice. During the past 14 years we have found many shipments of oil which were not pure lard oils, but were apparently mixtures of lard oil with some product which came from beef. On tracing out the matter by inquiry among the manufacturers who made the oil, it was found in certain portions of the country, and especially during the months of May, June and July, quite large amounts of grease could be obtained which contained considerable percentages of material from beef. As will be explained further on, tallow oil is simply nothing but the soft, oily part of the tallow separated from the stearin, in the same manner that the lard is separated from the stearin of the lard, and in reality these oils were mixtures of lard oil with oily matter from beeves. It usually does not pay to attempt to make oil from the tallow of country-fed cattle, the amount of oil obtained being so small; but if the cattle have been fed on distillery slops the amount of oily material is apparently largely increased, and this objection no longer remains. In the case above cited, where the source of the stock making this mixed oil was known, the stock came from regions where there were large distilleries. This peculiarity in regard to mixed lard and neat's-foot or tallow oils applies only to the *extra No.* 1 grade, and no serious difficulties have ever been experienced with the mixed oil in service. The reason why for the restriction in the specifications is more to enable the railroad company to be sure that it is not buying mixtures of various oils under the name of a pure product, than because of inability to use the mixed product.

The explanation of the method of buying on sample, and of the color of the samples, have already been stated. The requirement that shipments should be made as soon as possible after the order is placed is for the sake of keeping the stock on hand as small as possible. Orders are placed for these grades of oil once a month, and if a delay of two or three weeks occurs in making the deliveries, the various shops get out of supplies.

There are some places in the country where summer and winter oils are still made, and in order to allow these to compete it has been found essential to use a cold test at certain seasons of the year. At present the limits are from October 1 to May 1. It is, of course, fair to say that if the autumn proves warm there is no real necessity for a cold test until cold weather begins; but as this cannot be foreseen, the time of the cold test has to be made purely arbitrary. Considerable difficulty, more especially with certain of the petroleum products used for lubrication, is experienced if any inspection point is caught by a cold snap with a heavy stock of summer oil.

The tests made use of are directed to obtaining three results: First, to prevent an inferior grade being sold under the name of a better grade; second, to prevent the admixture of other oils with the kind bought; third, to secure such a quality of each oil as will give the best results in service. For the first of these points—the prevention of the acceptance of an inferior under the name of a better grade of oil—we rely largely on the amount of free acid, color and odor also being used. The method of determining the amount of free acid and the reasons why for each of the steps has already been given in the article in this series on "Tallow." The method is repeated above as part of the specifications for lard oil. In the prime grade color is not taken into account. In the *extra No.* 1 grade color has its influence, as has already been described. It is quite possible that the free acid test to protect against receiving inferior materials of a low grade would break down under certain conditions. For example, it is possible to make an oil from some of the so-called "yellow greases" of the market, which would not exceed the limits of free acid above mentioned in the specifications for extra No. 1 lard oil, but in our own experience this is very rarely if ever done. If such material should be offered it would be very easy to reject it on color and odor, or to so modify the specifications as to exclude it. Our experience has not indicated the necessity for this, however, and if the limits of the specifications are maintained, oil unadapted to the work, so far as receiving inferior material under the name of a better is concerned, will probably rarely occur.

Under the head of the quality of the oil, the cold test, and the adaptability of the oil to the service required of it, is comprehended. The method of making cold test is described in the specifications. It consists in brief in freezing the oil and then allowing it to thaw while a thermometer is in it, calling that temperature the cold test when the material in the bottle has sufficiently softened so that the mass will run from one end of the bottle to the other. In actual practice we find that the oil does not look like oil, but rather like a soft grease, when this point is reached. We are well aware that this method of making cold test is not the one in customary use. The ordinary practice is to place the bottle containing the oil in a freezing mixture or surrounded by cold, a thermometer suspended from the

cork having been placed with its bulb just below the surface of the oil, in the center of the bottle. The thermometer is read when the oil surrounding the bulb is just on the point of congealing, and this reading is regarded as the cold test of the oil. We formerly used this method, but abandoned it after very careful experimentation, the reason being that we could not get uniform results—that is, different tests on the same oil did not give the same results. According to our experience the cold test in this method is affected by the rate at which the oil cools, and is also not the cold test of the mass, but the cold test of those constituents of the oil which congeal at the lowest temperature. Furthermore, the method requires constant watchfulness on the part of the operator in order to seize the right moment when the last of the oil congeals. In order to make some of these points clear, it will be necessary to state that most, if not all, the oils of which cold tests are made contain constituents of different solidifying points, and when oil is exposed in a bottle to a sufficiently low temperature, so that any or all of the constituents will solidify, those constituents which solidify at the highest temperature apparently solidify first around the sides of the bottle, leaving the more limpid constituents unsolidified and crowded toward the center of the bottle. This process goes on gradually, effecting a separation of those constituents which have the lowest solidifying point, so that in reality by the common method, as above described, the cold test is simply the cold test of those constituents of the oil which have the lowest solidifying point. The separation of the constituents by cooling is affected by the rate of cooling. If the cooling is very rapid, the separation is much less; if it is slower, separation is much greater, and this often leads to variations in results in the same sample, as above described. In our method, however, it is believed these results do not follow. One of the principal reasons for taking cold test is to secure an oil which will run from the can, and consequently we have chosen that point at which the oil will run from one end of the bottle to the other as representing the cold test. Furthermore, it will be noticed that we mix the oil thoroughly with the thermometer while it is melting, and so we get the cold test of the whole oil and not a fraction of it. It is fair to state that with careful manipulation duplicate results can be obtained within one degree, although we do not usually enforce the results of this test as closely as this. It is also fair to state that the whole criticism above of the method of making cold test is much more applicable to petroleum products than lard oils, and some further statements in regard to cold test and methods of making will be made in a subsequent article on Petroleum Products.

It will doubtless be a surprise to many who are acquainted with the literature of the case to know that we regard the nitrate of silver test more as a test of quality than of purity, since that test, not exactly as described in the specifications, but with certain modifications, is generally supposed to be a test for the presence of cotton-seed oil. The complete test, we believe, is known in the literature of the case as Bechi's test. Our experience with the test, however, indicates that it is not reliable as a test for the presence of cotton-seed oil. It is not applicable to *extra No.* 1 lard oil, in the condition in which it is received from the manufacturer, under any circumstances, either pure or adulterated. The brownish color which is characteristic when cotton-seed oil is present is also produced by certain substances in the *extra No.* 1 lard oil, so that lard oil of that grade, containing no cotton-seed oil whatever, might test as though it had a large percentage of cotton-seed oil. This difficulty has been overcome, it is claimed, by the modification proposed by Millian, which consists in saponifying the oil, separating the soap, and then decomposing the soap. This, it is claimed, gives the free fat acids unmixed with any other substances, and which can be tested with nitrate of silver. If they show the brownish coloration it is evidence of the presence of cotton-seed oil.

It will be observed that we use the nitrate of silver test only on the best grade of lard oil. The necessity for some test of this kind arises in our experience from finding that much of the extra lard oil which was obtainable in the market did not give satisfactory results on burning test, although it would pass all the tests of our previous specifications. The characteristics of these extra lard oils during burning were serious coating of the wick and shorter length of time that the flame would maintain itself without retrimming. It has already been stated that when a lard oil contains large amounts of free acid, or when it has become somewhat old, it does not give satisfactory results as a burning oil. To such an extent is this true that, although we have tried many times to make a signal oil, using the cheaper or *extra No.* 1 grade in the market, we have never succeeded in getting an oil which would give a satisfactory light for more than 10 or 12 hours, and have never felt willing to trust such an oil. So far as we can decide, the reason why *extra No.* 1 lard oil does not give good results in burning is apparently a question in part of the amount of free acid, since, as previously stated, free oleic acid seems to have more of a tendency to oxidize and become resinous than olein alone. The presence of free acid, however, does not account wholly for the difficulty, since an oil containing almost no free acid will in time lose its burning qualities, as has already been explained. Also, it is possible to obtain in the market oils containing not more free acid than our specifications allow, which have been produced from extra No. 1 or lower grades of oil, by removing the free acid. These oils pass the ordinary tests, and in appearance are satisfactory as prime or extra lard oil, but when made into signal oil they do not give satisfactory results. Both these effects—namely, the deterioration of the best grade of oil by time, and also the behavior of oil from which the free acid has been removed, lead us to the idea that there is, or is developed by time, in lard oil of both grades, something which is detrimental to its burning qualities. Just exactly what this is we are unable to say. Our suspicion is that it is nitrogenous matter, coming originally from the tissues, and which is more or less gluey in its nature. It is also possible resinous matter may be developed by slow oxidation. Whatever the material is, we found a necessity for some test that would enable us to reject oil which will not give good results after it is made into signal oil. The most obvious test would be simply to make up a small batch of signal oil and make burning test, but this test is too slow. We are frequently called upon to give a decision in regard to 10 or 15 shipments in a day, and a burning test requires anywhere from 20 to 30 hours of continuous burning. In our experience the nitrate of silver test accomplishes this very purpose—namely, an extra or prime oil which becomes brownish when treated as described in the specifications, with the nitrate of silver test gives poor results in burning. We do not attempt to say whether these poor results are due to an admixture of cotton-seed oil or to an oil made from old lard or from a purified extra No. 1. Whatever the cause, the nitrate of silver test gives us a means of excluding oils which our experience indicates are not such oils as we want.

Two points in the method of testing as described are worthy of note. It will be observed that it is suggested to filter the oil through washed filter paper before making the test. The reason for this is that it has been found that many oils contain suspended matter, apparently bits of tissue which affect the test. These bits of tissue or other suspended matter settle out after the oil is made into signal oil, and do not cause any difficulty in service, and we therefore recommend to remove them by filtering before testing with nitrate of silver. It will also be observed that a statement is made in the specifications that satisfactory oil shows no change of color under this test. It is fair to say that we find few samples of extra or prime lard oil which show no change of color whatever, and that therefore if the strict wording of the specifications was followed it would probably be difficult to obtain in the market sufficient oil to supply the road. We spent considerable time in trying to define a limit of change of color. As stated above, the change produced by the treatment with nitrate of silver is a more or less brownish coloration, and we tried to give a limit of change of color beyond which we would not go. Any one who has attempted to define shades will appreciate the difficulty. We meet this difficulty in this case, as in all cases in our specifications where a little ambiguity seems to be unavoidable, by the

use of a little good common sense. We do not reject shipments of oil which show very slight changes of color on test. More marked changes are ground for rejection, the rule being that the change should be so marked that the manufacturers or dealers would, if they are fair, say that the oil did not pass test. The Pennsylvania Railroad specifications are not intended as devices to snap people up on technicalities, but to secure in the market such materials as will be an honest equivalent for the money paid for them, and will give the service that is required. Some manufacturers regard the nitrate of silver test as too sensitive and delicate for practical use, and are inclined to complain a little at the decisions reached by it. Our experience now for a number of months with this test, using, as said above, good ordinary common sense along with it, has convinced us that it is a very valuable one, and we should be very much disinclined to accept shipments of extra lard oil without testing them in this way. It should be remembered that the amount of this grade of oil that railroad companies use is not very large at the most, and that the results depending on this oil are very important, and we cannot help feeling therefore that railroad companies are entitled to the best oil of this grade that the market affords.

It is at present possible to mix with lard oil of either grade two kinds of cheaper oils as adulterants. These oils may be classed as non-saponifiable and saponifiable adulterants. The petroleum products and rosin oil are examples of non-saponifiable adulterants, and cotton-seed oil the best example at present prices of saponifiable adulterants. In trying to exclude these adulterants we rely partly on what is known as Maumene's test, or Hubl's iodine test, or possibly Millian's modification of Bechi's test with others, and also partly on quantitative saponification. Maumene's test, as is well known, is simply a measurement of the rise in temperature produced when certain amounts of the sample to be tested are mixed with strong oil of vitriol. We usually use 20 cubic centimeters of the oil sample and 10 cubic centimeters of the oil of vitriol. The oil sample having been placed in a small beaker, the oil of vitriol is added and the two are mixed by stirring with a thermometer, care being taken to have both the ingredients, the thermometer, and the dish at the same temperature, usually 80° Fahrenheit, when the mixing begins. Under these conditions a rise of temperature of about 80° is obtained when the lard oil is pure. Samples of pure lard oil vary a little in our experience, but usually not more than three or four degrees. We think these variations in pure oils are due probably to variations in the proportions of the stearin and olein in the sample, since our experience shows that stearin gives a lower rise in temperature than olein. We also find that the strength of the oil of vitriol and the beaker and thermometer used affect the test somewhat. Our usual method is to take a carboy of oil of vitriol from the market and make a test with a sample of the oil which we know to be pure. This test, repeated several times, gives us what that oil of vitriol will do with pure oil, and as long as that carboy holds out, care being taken to exclude moisture, that figure can be taken as the rise in temperature for pure oil. The peculiarity in regard to the beaker and thermometer is a little singular. Two beakers of apparently the same size, and two thermometers tested in exactly the same way with the same oil and same oil of vitriol, will not give the same rise in temperature. There seems to be a characteristic of each beaker and each thermometer. It is, of course, understood that in making this statement we do not rely on a single figure for the different beakers. Enough tests in the same beaker are always made to eliminate accidental differences, and so convinced are we of this peculiarity of beakers and thermometers, that whenever a new lot of beakers are obtained we always make a number of tests with each beaker with its thermometer to get the characteristic of the beaker, and then scratch it on the glass with a diamond point. We are unable to account for this peculiarity. It seems probable, however, that the rate of transmission of heat through the sides of the beaker will do something toward explaining it. Usually the test is made without any non-conducting cover to the beaker, and if one beaker loses heat more rapidly than another, obviously not the same rise in temperature would be obtained in the two. This same peculiarity of loss of heat during the time of making the test, approximately from half a minute to a minute, introduces another source of error—namely, the atmosphere at certain times apparently cools the beaker more rapidly than at others, thus occasioning a slightly different rise in temperature at different times, even with the same beaker. The error due to these variables may be sufficient to cause a wrong judgment to be passed in regard to an oil which is being tested, and accordingly we take great pains in all our tests to have all the conditions made as constant as possible. Maumene's test, being so simple and so easily applied, must be regarded as a very valuable one. Each kind of oil which we have run across in our experience has its own characteristic rise in temperature. As will be observed in the way in which we perform the test, pure lard oil gives a rise in temperature of about 80°. Tallow oil and neat's-foot oil give a rise in temperature some 12° lower; olive oil not far different from lard oil. Petroleum products give a very slight rise in temperature, sometimes not over 5° or 10°. Cotton-seed oil, on the other hand, gives a rise in temperature of 137°. Most of the other animal and vegetable oils give considerably higher rise in temperature than lard oil. Mixtures of oils give a rise in temperature somewhere between the limits of the two when tested alone. For example, a mixture of half tallow oil and half lard oil will give a rise in temperature of 74°, on the supposition that tallow oil gives a rise in temperature of 68° and lard oil 80°. Also a mixture of half lard oil and half cotton-seed oil would give a rise in temperature of 109°—that is, half way between 80° and 137°. It will thus be observed that if the sample of oil which is being tested does not give the characteristic rise in temperature corresponding to the oil which is supposed to be present, suspicion at once arises that some other oils are mixed with it. If the rise is above that of lard oil, some of the animal or vegetable oils giving a higher rise in temperature are suspected. If it is below, either petroleum product or some of the animal or vegetable oils giving a lower rise in temperature are suspected. In our experience, embracing now some eight or nine years, we have found in the market only olive oil, tallow oil, the petroleum products, and rosin oil which give a lower rise in temperature than lard oil. All of the other oils which we have tested, embracing the fish oils, and most of the animal and vegetable oils, give a higher rise in temperature.

The value of the Maumene test is very great, but it does not tell all that is required to be known; three cases might arise, as follows:

First, if the sample being tested gives a higher rise in temperature than is characteristic of lard oil, sufficient allowance being made for accidental rise, as above stated, we feel satisfied in saying that the oil is not pure lard oil from corn-fed hogs. The effect of the food on the oil has already been discussed.

Second, if the rise in temperature is that which is characteristic of lard oil, it is very strong evidence that the oil is pure, but not positive proof. The reason for this is that a mixture, for example, of tallow oil, neat's-foot oil, or rosin oil with cotton-seed oil may be made in such proportions as to give the rise in temperature which is characteristic of lard oil, so that actually a sample which contains no lard oil whatever, if tested by Maumene's test alone, might be pronounced pure lard oil. The proportion of cotton-seed oil, however, to produce this result would be at least 25 per cent., and so large a percentage of cotton-seed oil could easily be detected by Millian's modification of Bechi's test, unless perchance the cotton-seed oil was treated in such a way as to cause it to fail to give reaction with Bechi's test. This, of course, is possible, and in this case further study would have to be put upon the sample and tests made, which it is hardly within our present purpose to describe. Our object now is to give the methods in common use in well-known laboratories for testing.

Third, if a sample in question causes a rise in temperature with Maumene's test, lower than corresponds to pure lard oil, the presence of tallow oil, neat's-foot oil, or of some of the petroleum products or rosin oil would be suspected. If tallow oil, neat's-foot oil, or olive oil is

present, there would very little difficulty arise in the service, as all of these oils are about as good for all purposes as lard oil, and at present their prices are such that there would be very little tendency to use them as adulterants. If petroleum products or rosin oil were present, however, the results in service would be not so good, and also there would be quite a wide margin for fraud. To check up this test a saponification test is made. Pure lard oil requires a certain amount of caustic soda or potash to completely saponify any given amount. If now any given sample is treated with an amount of soda or potash sufficient to saponify it, and it is found by the subsequent operation that all the potash or soda is not used up, it is proof positive either that the saponification is not complete or that the oil contains some constituents which do not saponify. The process is so simple and so well understood by those making oil tests that it is probably unnecessary to describe it. We use an alcoholic solution of potash, and determine the amount of potash not used up by titration with standard acid, using phenolphthalein as indicator.

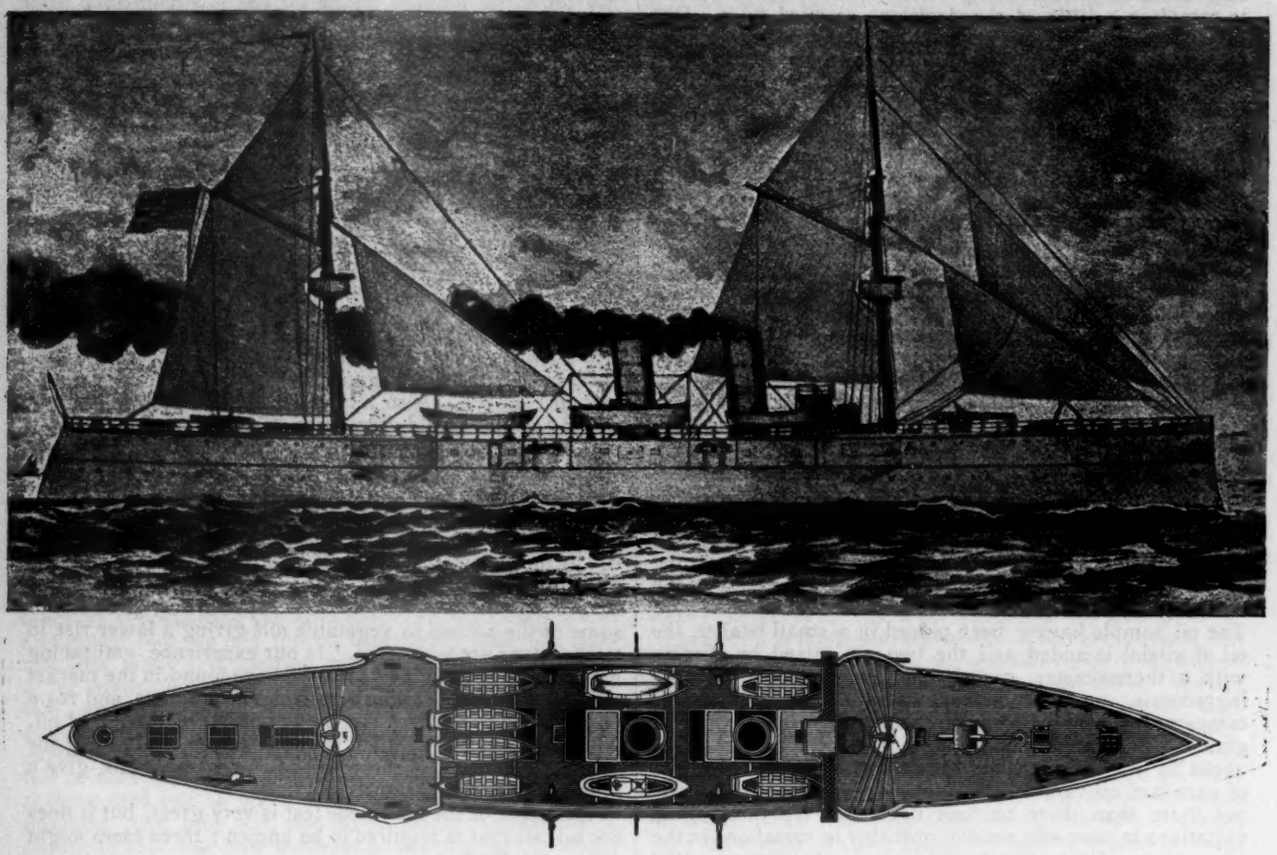
Hubl's test, which is based on the amount of iodine absorbed by certain fatty bodies when treated in the proper way, is similar in the results which it gives to Maumene's test—that is to say, if an oil gives a high rise in temperature with Maumene's test, it will usually but not always give a high absorption with Hubl's test. We think Hubl's test is valuable as a means of confirmation, or for investigation, or to help us decide a point, but in general its indications being so similar, and Maumene's test being so much simpler, we usually use Maumene's test.

It will thus be seen that we have two very simple tests—namely, Maumene's test and saponification, and that by means of these it is possible to pronounce quite positively whether a certain sample of oil is pure lard oil or not, the only exception being with all such mixtures as would give the same rise in temperature with Maumene's test as pure lard oil does, and the same saponification equivalent. As stated above, such cases in our experience are rather rare, and are met in our Laboratory by other tests which we do not deem it essential to describe here.

In concluding this perhaps too long article, it would probably be well to say that the freedom of the sample sent for test from admixtures of other oils is a point which needs to be looked after pretty carefully. In the system in use on the Pennsylvania Railroad the sampling of the shipments is done at the various shops where the shipments are received by an employé of the Company, and it has required considerable discipline to have the sample sent always in either a clean can or in a can which has been used for no other kind of oil except the kind of oil sent. All who have had any experience in this line will recognize at once what disastrous results would follow the sending of a sample of water white petroleum in a can which had been used for well oil, and not cleaned, and also sending a sample of extra lard oil in a can which had previously been used for extra No. 1 lard oil.

The next article of this series will be on the Petroleum Products used by railroads.

(TO BE CONTINUED.)



CRUISERS NOS. 7 AND 8 FOR THE UNITED STATES NAVY.

UNITED STATES NAVAL PROGRESS.

BIDS for the two 1,000-ton gun-boats—officially known as gun-boats Nos. 5 and 6—and for the practice ship for the Naval Academy, have been received. The Bath Iron Works, Bath, Me., bid $327,000 for one gun-boat, or $637,000 for the two. The Samuel L. Moore & Sons Company, Elizabeth, N. J., bid $285,000 for one gun-boat, $562,875 for two gun-boats, and $245,325 for the practice vessel. The Atlantic Iron Works, of Boston, bid $344,000 for one gun-boat. It is not yet decided to whom the contracts for these vessels will be awarded. Neither of these establishments has built any vessels for the Navy before.

The practice ship is to be 180 ft. in length, 32 ft. breadth, 11 ft. 6 in. mean draft, and 835 tons displacement. She will

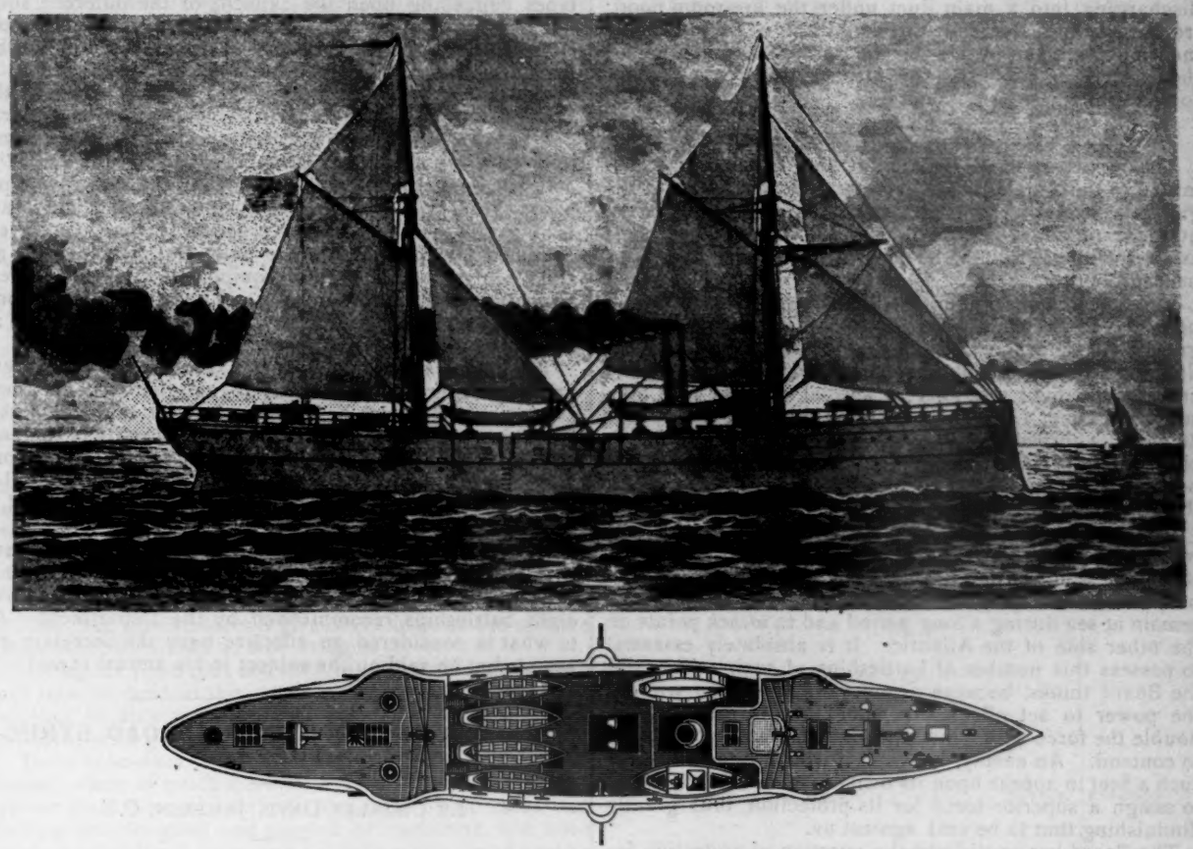
have a battery of four 4-in. rapid-fire guns, with a secondary battery of machine and Gatling guns. The engines will be of the triple-expansion type and of some 1,300 H.P. The vessel will have all the appliances of the modern cruiser, including electric lights, torpedo-tubes, etc.

The gun-boats Nos. 5 and 6 are to be small, fast twin-screw, steel cruisers, carrying on a small displacement a battery of rapid-fire guns and a large supply of coal. The main dimensions will be: Length on load-line, 190 ft.; breadth, 32 ft.; mean draft, 12 ft.; displacement, 1,000 tons; indicated power of engine, 1,600 H.P. They will have double bottoms, and the machinery will be protected by the coal bunkers and by bulkheads filled with woodite.

The main battery will consist of eight 4-in. rapid-fire guns, one on the poop, one on the forecastle, two under the forecastle mounted in sponsons, two under the poop in sponsons, and two amidships, also in sponsons. The secondary battery will consist of two 47-mm. and two 37-mm. revolving cannons, one one-pounder and one Gatling gun.

The engines will be of the vertical, inverted-cylinder, direct-acting, triple-expansion type, each with cylinders 15 in., 25 in. and 34 in. in diameter and 24 in. stroke. Steam will be supplied by four boilers 10 ft. in diameter and 17 ft. 6 in. long. The coal bunkers will hold 250 tons, and the cruising range on this supply will be 2,452 knots at 14 knots an hour, or 4,668 knots at 10 knots. There will be a steam steerer and steam windlass.

The rig, as shown in the accompanying illustrations—which are taken from the Report of the Bureau of Construction, and show a general view and deck plan—will be that of a schooner with a fore-yard and square foresail.



GUNBOATS NOS. 5 AND 6 FOR THE UNITED STATES NAVY.

THE 3,000-TON CRUISERS.

Contracts have been let for most of the material for the new cruisers Nos. 7 and 8—the 3,000-ton cruisers—and the keel of No. 7 has been laid at the Brooklyn Navy-yard. This ship and the engines of both vessels will be built in that yard, while No. 8 will be built at the Norfolk Navy-yard. The general design of these ships is shown in the illustrations on page 126—taken from the annual report of the Bureau of Construction and Repair—which show an elevation and deck plan.

They will be twin-screw steel cruisers, with heavy protective deck. The latter slopes at the sides in two slopes of 22° and 39°; it will be 2½ in. thick on slopes amidships, 2 in. on slopes at ends and 1 in. on the flat. A coffer-dam is worked along in wake of the water-line next the outside plating in the coal bunker on the slope of the protective deck. This will be filled with woodite. They will have double bottoms throughout. The rudder will be of the balanced type.

The ships will be provided with electric lights throughout. The ventilation will be on the exhaust system.

The capacity of the coal bunkers will be 556 tons; with this supply the radius of action at various speeds will be: 20 knots per hour, 1,243 knots; 18 knots, 2,213; 16 knots, 2,964; 14 knots, 4,190; 12 knots, 5,925; 10 knots, 8,652; 8 knots, 9,982. Thus at an average speed of 10 knots an hour they can keep at sea 36 days without coaling.

The general dimensions of these ships are: Length on load-line, 300 ft.; extreme breadth, 42 ft.; mean draft, 18 ft.; displacement, 3,183 tons; indicated H.P. of engines, 10,000.

The armament will consist of one 6-in. breech-loading rifle, mounted on the topgallant forecastle as a forecastle pivot, and one 4-in. rapid-fire gun mounted on each side of the poop. In broadside on the spar deck there will be eight 4-in. rapid-fire guns, four on a side, the forward and after guns of each broadside being sponsoned for bow and for stern fire. The secondary battery will consist of two six-pounder and two three-pounder rapid-fire guns, two 37-mm. revolving cannon, and two Gatlings. In addition, they will be fitted with six torpedo tubes, disposed one in the bow, one in the stern, and two on each broadside.

The engines are triple-expansion, vertical, inverted and direct-acting, with a high-pressure cylinder 36 in., intermediate 53 in. and two low-pressure, each 57 in. in diameter, the stroke being 33 in. The condensers have each 7,000

ft. of cooling surface. There is a double, vertical, single-acting air-pump worked by a vertical compound engine for each engine. The circulating pumps are centrifugal, one for each condenser worked independently. The engines will be supplied by steam from four main boilers, two of them being 13 ft. 4 in. and the other two 14 ft. 6½ in. in diameter, and all of them 20 ft. 3½ in. long. These main boilers are double-ended. There are two auxiliary boilers, single-ended, 11 ft. 2 in. in diameter by 9 ft. 0½ in. long. The working pressure will be 160 lbs. The total heating surface is 19,382 sq. ft. and the grate surface 597 sq. ft. The forced draft system consists of a blower discharging into a main duct under the fire-room floor; from it a branch duct is led to the ash-pit of each furnace, means being taken for closing the ash-pits and preventing the leakage of gas from the furnace doors when under forced draft.

THE NAVAL POLICY BOARD.

The report of the Naval Policy Board has been transmitted to the Senate by the Secretary of the Navy. It begins by considering at length the work which may be required of the Navy in case of war, and also the conditions existing with respect to the construction of the new ships needed.

The Board is of opinion that the following vessels should be added to the United States Navy: Ten battleships of great coal endurance; 25 battleships of limited coal endurance; 24 cruisers of 4,000 tons and over; 15 torpedo cruisers of about 900 tons; 5 special cruisers for China service of about 1,200 tons; 10 rams for coast and harbor defense; 3 torpedo-depot and artificers' ships; 100 first-class torpedo boats and numerous second-class torpedo boats, carried by the battleships of great endurance and the larger cruisers and torpedo-depot ships.

In general terms the battleships of great coal endurance would constitute the basis of a fleet which might be detached in whole or in part for distant service and for the purpose of cruising against the enemy, having the power to remain at sea during a long period and to attack points on the other side of the Atlantic. It is absolutely essential to possess this number of battleships of such endurance, the Board thinks, because a policy of protection without the power to act offensively would at the present time double the force with which the United States would have to contend. An enemy, knowing it would be possible for such a fleet to appear upon its own coast, would be obliged to assign a superior force for its protection, thus greatly diminishing that to be sent against us.

The Board has considered the question of protection for guns and crews of cruisers, and believes that, within certain limits, the weight assigned to such protection is far more useful than the same weight in additional guns.

The following summary gives the distribution of the elements of the fleet, including all vessels built, building, appropriated for and recommended by the Board:

Battleships of Great Endurance.—Thirteen vessels, of an aggregate tonnage of 120,450 and total cost of $67,400,000.

Battleships of Limited Endurance.—Twenty-five vessels, of an aggregate tonnage of 179,200 and total cost of $110,000,000.

Harbor Defense and Rams.—Seventeen vessels, of an aggregate tonnage of 62,320 and total cost of $44,500,000.

Cruisers of All Classes (including gun vessels and dispatch boats).—Sixty-eight vessels, of an aggregate tonnage of 225,500 and total cost of $114,460,000.

Torpedo Depot Boats and Artificer Ships.—Three vessels, of an aggregate tonnage of 15,000 and cost of $6,500,000.

Sea-going Torpedo Boats.—One hundred and one, of an aggregate tonnage of 6,565 and cost of $6,565,000.

Total cost, $349,515,000, of which $67,965,000 is already expended or appropriated.

Reliance is placed on the development of an auxiliary navy of fast, well-built merchant steamers, to supplement the rather small proportion of cruisers contemplated in the programme.

One of the chief obstacles to carrying out this naval programme is the absence of a source of armor supply. There is only one establishment able to furnish the required armor, and unless others are prepared no large quantity of armor can be delivered before 1895. But the Board believes that if Congress will make appropriations immediately for a considerable number of heavily armored ships the demand for armor will induce the development of other large plants.

The best policy lies in concentrating available energy upon such a number of ships as can be completed in a reasonable time, and the efficiency of their type made available as soon as possible. The Board, therefore, believes that about 70,000 tons may profitably be laid down in the next two years, the distribution among the different types depending upon the capacity of the different ship-building establishments of the country. As much as possible of this aggregate tonnage, however, should be in battleships. It is believed that the work can be carried on at the following rate: 14 per cent. to be laid down in the first and second years, 10 per cent. in the third and fourth and 12 per cent. in each succeeding year, the programme to be completed in 14 years.

It is contemplated and urged that the four principal Navy-yards—viz., New York, Boston, Norfolk, and Mare Island, will be in the least practicable time completely equipped for constructing the hulls and machinery of all classes of vessels and their equipment, and with largely increased facilities for docking. The Board also recommends that the League Island Navy-yard be equipped as soon as possible for the construction of hulls of vessels.

The Board recommends that a wide series of artillery and torpedo experiments be made, and that to begin these experiments $100,000 be appropriated for immediate use. The Board also calls attention to the necessity of increasing coaling facilities at navy-yards and coaling stations and for coaling ships at sea. It is believed that suitable appliances can be determined upon and readily applied to ordinary colliers.

In his letter of transmittal the Secretary of the Navy says he does not coincide with the Board entirely. He is satisfied of the capacity of this country to complete the eight battleships recommended by the Department. As to what is considered an effective navy the Secretary repeats what he said on the subject in his annual report.

THE USE OF WOOD IN RAILROAD STRUCTURES.

By Charles Davis Jameson, C.E.

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(*Continued from page 80.*)

CHAPTER XXII.

HOWE TRUSS BRIDGES.

The following plans of Howe Truss Bridges are not in strict conformity with the standard designs of any one railroad company. The Author has departed from these standard designs for the following reasons:

1. Comparing the designs in use upon the various roads in this country, much discrepancy was found to exist, not only in the details of construction, which might be expected, but in the actual size of the timbers used in the trusses. On different roads using the same type of locomotives and rolling stock, differences of such an amount exist as to make a divergence of not less than 50 per cent. in the actual strength of the trusses. One reason of this great difference is due undoubtedly to the fact that some of the designs were made some 10 years ago, and although they were forwarded to the Author during the last two years, it is to be hoped and is probably the case that the roads which furnished these plans are not now using them as standards.

2. There were no standard plans available that presented in consecutive order the lengths of spans desired, although we have a collection comprising spans of different lengths from the majority of railroads using Howe truss bridges in the country. Many of these bridges in use are badly de-

signed, and with very few exceptions none of them were intended to withstand the strain brought upon them by the present excessive locomotive and train loads.*

By the engineer or student of engineering in the East, the important part that wooden bridges not only form at present but will form for many years to come in our railroad systems, is not realized. On the older roads and on all roads running through the most thickly settled portions of the country, iron or steel bridges are either in actual use at present or any wooden bridges that do still exist will soon be replaced by metal. But on our Western roads and on all new roads in sparsely settled countries this is not the case, and for bridges not exceeding 150 ft. in span the Howe truss bridge, with compression members and bottom chord of wood still is and will continue to be the typical bridge. As to the actual amount of wooden bridging and trestling now in use upon our railroads, the following figures are taken from "Cooper on American Railroad Bridges" (*Proceedings American Society of Civil Engineers*, Vol. XXI., page 46).

From the previous figures, it would appear that there are now in existence on our railroads the following wooden and combination trestles and bridges:

Trestles and Spans under	20 ft	2,407	miles.
Spans wooden truss	20– 50 ft	35	"
" "	50–100 ft	64	"
" "	100–150 ft	97	"
" "	150–200 ft	40	"
" "	over 200 ft	7	"
Total		2,650	"

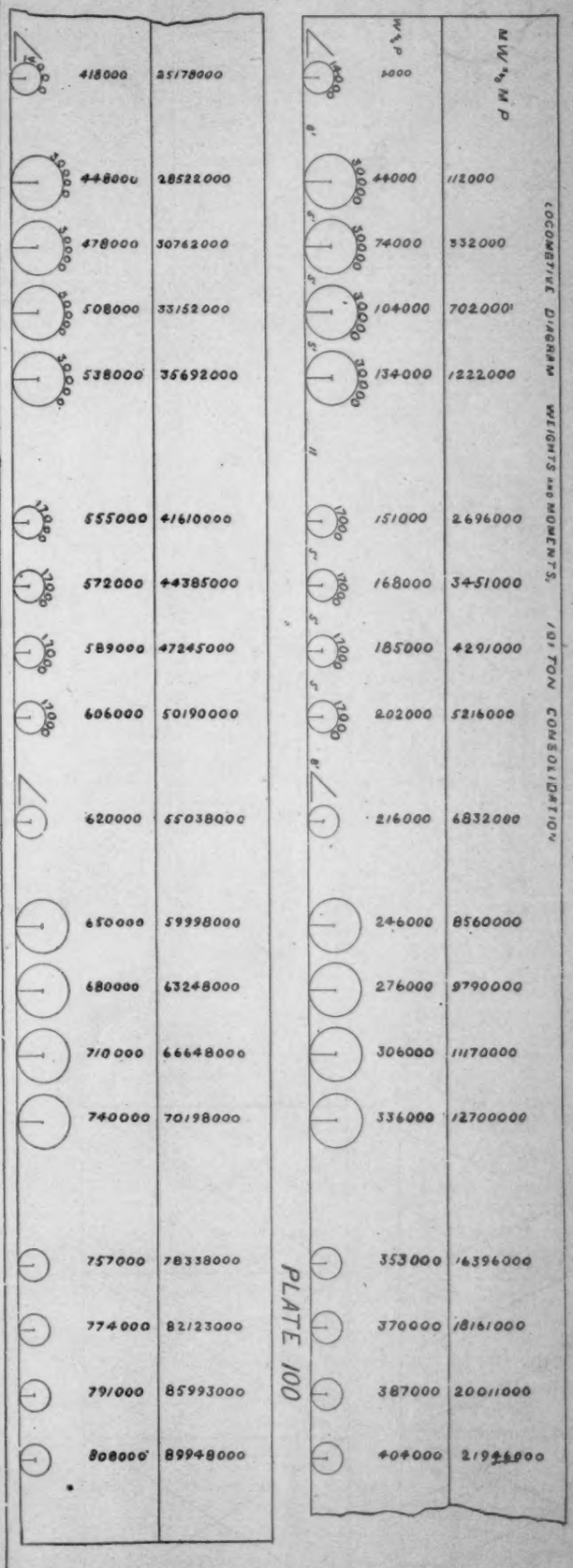
Of the 2,400 miles of trestle we can consider one-quarter as only temporary to be filled in as embankment. Of the remaining 1,800 miles 800 at least will be maintained in wood. This would give us ultimately 1,000 miles of wooden trestles and bridges and 1,600 miles of iron bridges on our 160,000 miles of railroad, of which only 380 miles are of iron up to the present time.

This free quotation will give some idea of the relative importance of wood and iron bridges.

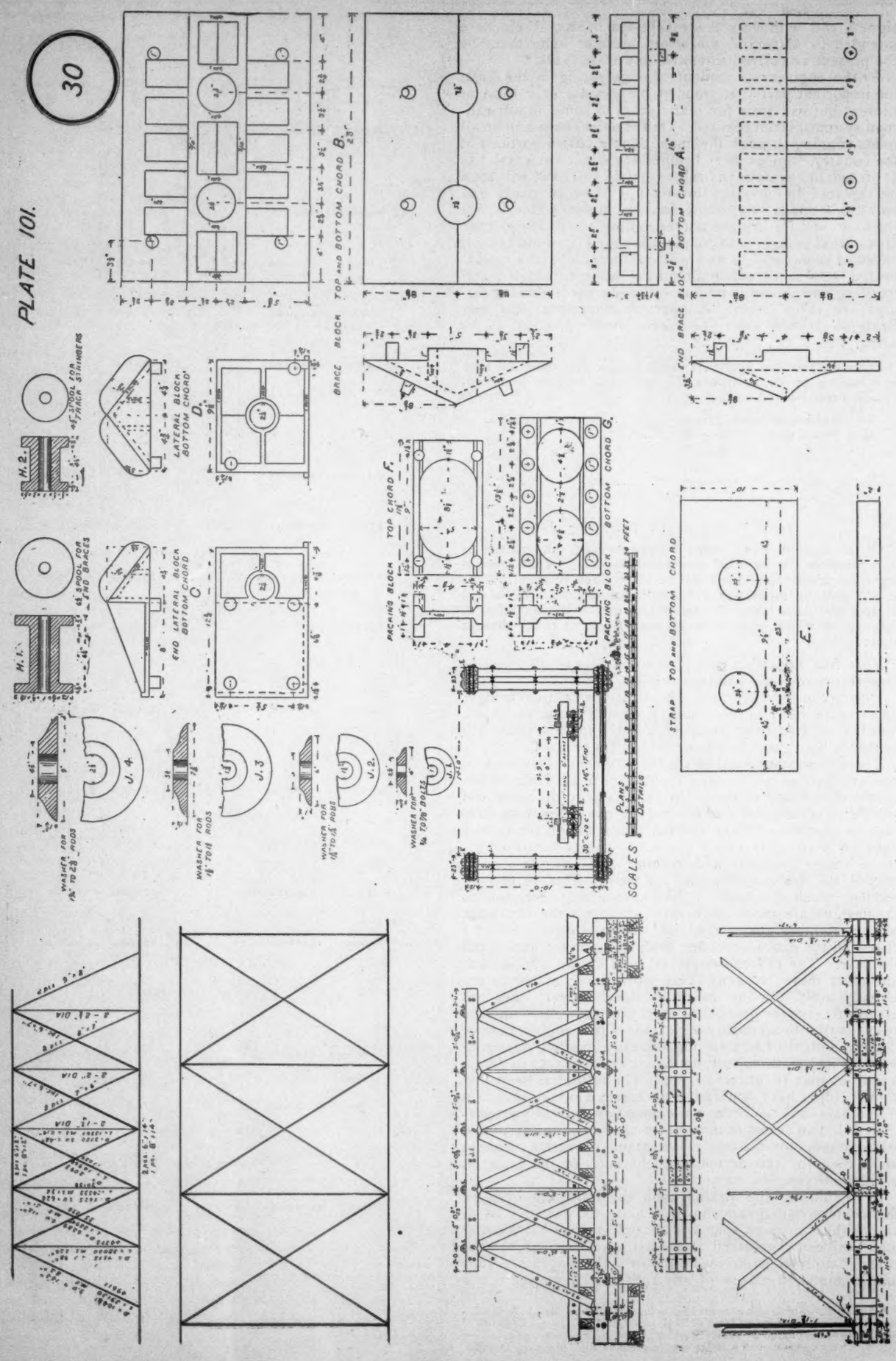
During the years 1887 and 1888, of all the railroad bridges and trestles built in this country, over 75 per cent. of the number of structures were of wood, and this ratio will probably hold good for the next 20 years at least.

There is another point in regard to wooden bridges that renders them of much more importance to the railroad engineer than those of iron. In the majority of cases iron bridges are designed and erected by engineers who have made a specialty of them, and the railroad engineer usually does no more than check the strain-sheets furnished by some bridge company and examine and criticise the details of the designs furnished by them. This, of course, reduces much the work of the railroad engineer, and as the designs are made by experts, improves the character of the iron bridges erected and materially reduces their cost. In the case of wooden bridges, however, this is not the case. The railroad engineer must design, proportion, and erect these bridges. This work being added to the already multitudinous duties of the engineer, does not always receive the amount of attention necessary, and the result is that in a number of instances the engineers have taken the plans of some bridge already erected, changing some of its details to suit the new circumstances as far as length of span is concerned, etc. The result has been that some bridges have double the necessary amount of material, others have too little, while others are so badly proportioned that an excess of material is used on some members, while others only manage to withstand the strain brought upon them by the exceptional character of the material accidentally used.

In calculating the strains upon the following bridges, the locomotive diagram shown in Plate 100 has been used, and as the maximum span will be only 150 ft., the moving load has been considered as consisting entirely of 101-ton consolidation locomotives, as shown in the diagram. This load is much in excess of any that has been used in the



* The Author wishes to acknowledge his indebtedness to Mr. A. A. Robinson of the Atchison, Topeka & Santa Fé Railroad, and Mr. George C. Smith of the Chicago, Burlington & Quincy Railroad, for their kindness in furnishing him with very complete and satisfactory drawings of their Standard Designs.


30
PLATE 101.
TOP AND BOTTOM CHORD B.
BRACE BLOCK
TOP AND BOTTOM CHORD A.
END BRACE BLOCK
H.2.
SPOOL FOR TRACK STRINGERS
LATERAL BLOCK BOTTOM CHORD
D.
H.1.
SPOOL FOR END BRACES
END LATERAL BLOCK BOTTOM CHORD
C.
PACKING BLOCK TOP CHORD F.
PACKING BLOCK BOTTOM CHORD G.
STRAP TOP AND BOTTOM CHORD
E.
J.4
J.3
J.2
J.1
WASHER FOR 7/8 TO 1 1/8 RODS
WASHER FOR 3/4 TO 7/8 RODS
WASHER FOR 5/8 TO 3/4 RODS
WASHER FOR 1/2 TO 5/8 BOLTS
PLANS
DETAILS
SCALES
FEET

No. 39. Bill of Material for Bridge of 30 Ft. Span. Plate 101.

Wood.

No. of Pieces.	Description.	Size.	Length.	Ft. B. M.	Kind of Wood.
4	Top Chord...	6 in. × 12 in.	24 ft. 0⅜ in.	576	Yellow Pine.
2	" " ...	8 in. × 12 in.	24 ft. 0⅜ in.	384	" "
4	Bottom Chord	6 in. × 14 in.	36 ft. 0 in.	1,008	" "
2	" "	8 in. × 14 in.	36 ft. 0 in.	672	" "
8	Braces...	9 in. × 8 in.	16 ft. 0 in.	768	" "
8	"	8 in. × 7 in.	16 ft. 0 in.	600	" "
8	"	7 in. × 6 in.	16 ft. 0 in.	448	" "
8	Counters... .	7 in. × 6 in.	16 ft. 0 in.	448	" "
6	Laterals.....	7 in. × 6 in.	17 ft. 6 in.	378	" "
2	"	7 in. × 6 in.	14 ft. 0 in.	98	" "
8	Bolsters.....	6 in. × 10 in.	7 ft. 0 in.	280	" "
4	"	8 in. × 10 in.	7 ft. 0 in.	128	" "
8	Bridge-seats..	6 in. × 10 in.	5 ft. 0 in.	200	" "
4	" " ..	8 in. × 10 in.	5 ft. 0 in.	134	" "
4	Sills.....	12 in. × 12 in.	18 ft. 0 in.	864	Spruce or Pine
14	Floor-beams..	9 in. × 16 in.	18 ft. 0 in.	3,024	" " "
6	Stringers.....	6 in. × 12 in.	36 ft. 0 in.	1,296	" " "
33	Ties.....	8 in. × 8 in.	12 ft. 0 in.	. ...	Oak.
2	Guards.....	6 in. × 6 in.	36 ft. 0 in.	216	Spruce or Pine
4	Plank.....	2 in. × 8 in.	36 ft. 0 in.	192	" " "
8	Blocks.... ...	2 in. × 8 in.	2 ft. 0 in.	22	Oak.

Wrought-Iron—Rods and Bolts.

No.	Description.	Diameter.	Length.	No.	Description.	Diameter.	Length.
8	Rods.	2½ in.	12 ft. 10 in.	12	Bolster.	1¼ in.	3 ft. 3 in.
8	"	2 in.	12 ft. 10 in.	14	Floor-beam.	1¼ in.	4 ft. 4 in.
4	"	1¾ in.	12 ft. 10 in.	24	Stringers.	¾ in.	2 ft. 6 in.
4	Laterals.	1¾ in.	18 ft. 6 in.	14	Ties.	¾ in.	2 ft. 6 in.
56	Chord-bolts.	¾ in.	2 ft. 0½ in.	14	Guards.	¾ in.	1 ft. 3 in.
20	Brace-bolts.	¾ in.	2 ft. 0½ in.	24	Spikes.	½ in.	9 in.
12	Bolster.	1¼ in.	2 ft. 2 in.				

Washers: 300 of pattern *I1*; 76 of *I2*; 8 of *I4*.

Castings.

Pieces: 4 of pattern *A*; 20 of *B*; 4 of *C*; 4 of *D*; 20 of *E*; 24 of *F*; 40 of *G*; 12 of *H1*; 16 of *H2*.

No. 40. Bill of Material for Bridge of 36 Ft. Span. Plate 102.

Wood.

No. of Pieces.	Description.	Size.	Length.	Ft. B. M.	Kind of Wood.
4	Top Chord....	6 in. × 12 in.	28 ft. 0½ in.	720	Yellow Pine.
2	" "	8 in. × 12 in.	28 ft. 0½ in.	480	" "
4	Bottom Chord	6 in. × 14 in.	42 ft. 0 in.	1,176	" "
2	" "	8 in. × 14 in.	42 ft. 0 in.	784	" "
8	Braces	9 in. × 8 in.	16 ft. 0 in.	672	" "
8	"	8 in. × 7 in.	16 ft. 0 in.	600	" "
8	"	7 in. × 7 in.	16 ft. 0 in.	528	" "
8	Counters.....	7 in. × 6 in.	16 ft. 0 in.	448	" "
6	Laterals.....	6 in. × 7 in.	20 ft. 0 in.	420	" "
2	"	6 in. × 7 in.	14 ft. 0 in.	98	" "
8	Bolsters.....	6 in. × 10 in.	8 ft. 0 in.	320	" "
4	"	8 in. × 10 in.	8 ft. 0 in.	214	" "
8	Bridge-seats..	6 in. × 10 in.	6 ft. 0 in.	240	" "
4	" " ..	8 in. × 10 in.	6 ft. 0 in.	160	" "
4	Sills.....	12 in. × 12 in.	18 ft. 0 in.	864	Spruce or Pine
14	Floor-beams..	9 in. × 16 in.	18 ft. 0 in.	3,024	" " "
6	Stringers.....	6 in. × 12 in.	42 ft. 0 in.	1,512	" " "
40	Ties.....	8 in. × 8 in.	12 ft. 0 in.	.....	Oak.
2	Guards.....	6 in. × 6 in.	42 ft. 0 in.	252	Spruce or Pine
4	Planks.....	2 in. × 8 in.	42 ft. 0 in.	224	" " "
8	Blocks.....	2 in. × 8 in.	2 ft. 0 in.	22	Oak.

Wrought-Iron—Rods and Bolts.

No.	Description.	Diameter.	Length.	No.	Description.	Diameter.	Length.
8	Rods.	2¾ in.	12 ft. 10 in.	12	Bolster.	1¼ in.	3 ft. 3 in.
8	"	2¼ in.	12 ft. 10 in.	14	Floor.	1¼ in.	4 ft. 4 in.
4	"	1¾ in.	12 ft. 10 in.	24	Stringer.	¾ in.	2 ft. 6 in.
4	Laterals.	1¾ in.	18 ft. 6 in.	14	Tie.	¾ in.	2 ft. 6 in.
56	Chord-bolts.	¾ in.	2 ft. 0½ in.	14	Guard.	¾ in.	1 ft. 3 in.
20	Brace-bolts.	¾ in.	2 ft. 0½ in.	24	Spikes.	½ in.	9 in.
12	Bolster.	1¼ in.	2 ft. 2 in.				

Washers: 300 of pattern *I1*; 76 of *I2*; 8 of *I4*.

Castings.

Pieces: 4 of pattern *A*; 20 of *B*; 4 of *C*; 4 of *D*; 20 of *E*; 24 of *F*; 40 of *G*; 12 of *H1*; 16 of *H2*.

standard designs in the possession of the Author, but considering the ever-increasing loads that are used in practice, it has not been considered so excessive as to be uneconomical.

The span of the bridge (which will in every case be found clearly marked upon the plan enclosed in a circle) is the number of panels multiplied by the length of one panel. In dimensioning the members, the following specifications will be followed:

Rods.—The allowable stress per square inch of sectional area not to exceed 8,000 lbs.

The ends of all rods to be upset so that the sectional area at the bottom of the thread shall exceed that of the main part of the rod.

Bottom Chord.—Allowable stress per square inch for tension not to exceed 800 lbs. of effective area, due allowance being made for bolt holes, etc.

In the shorter spans the amount of tension brought upon the bottom chord requires such slight sectional area, as compared with that necessary to resist the cross-strain due to the floor beams, that it may be entirely omitted in the calculation, and the bottom chord proportioned simply to support the floor beams and give sufficient stiffness and rigidity to the structure.

The top chord and braces are proportioned according to the following formula:

$$W = \frac{700}{1 + 1.5\left(\sqrt{1 + \frac{l^2}{900d^2}} - 1\right)}$$

Here W = allowable stress in pounds per square inch of sectional area,

l = length in inches of member between square ends.

d = depth of member in inches.

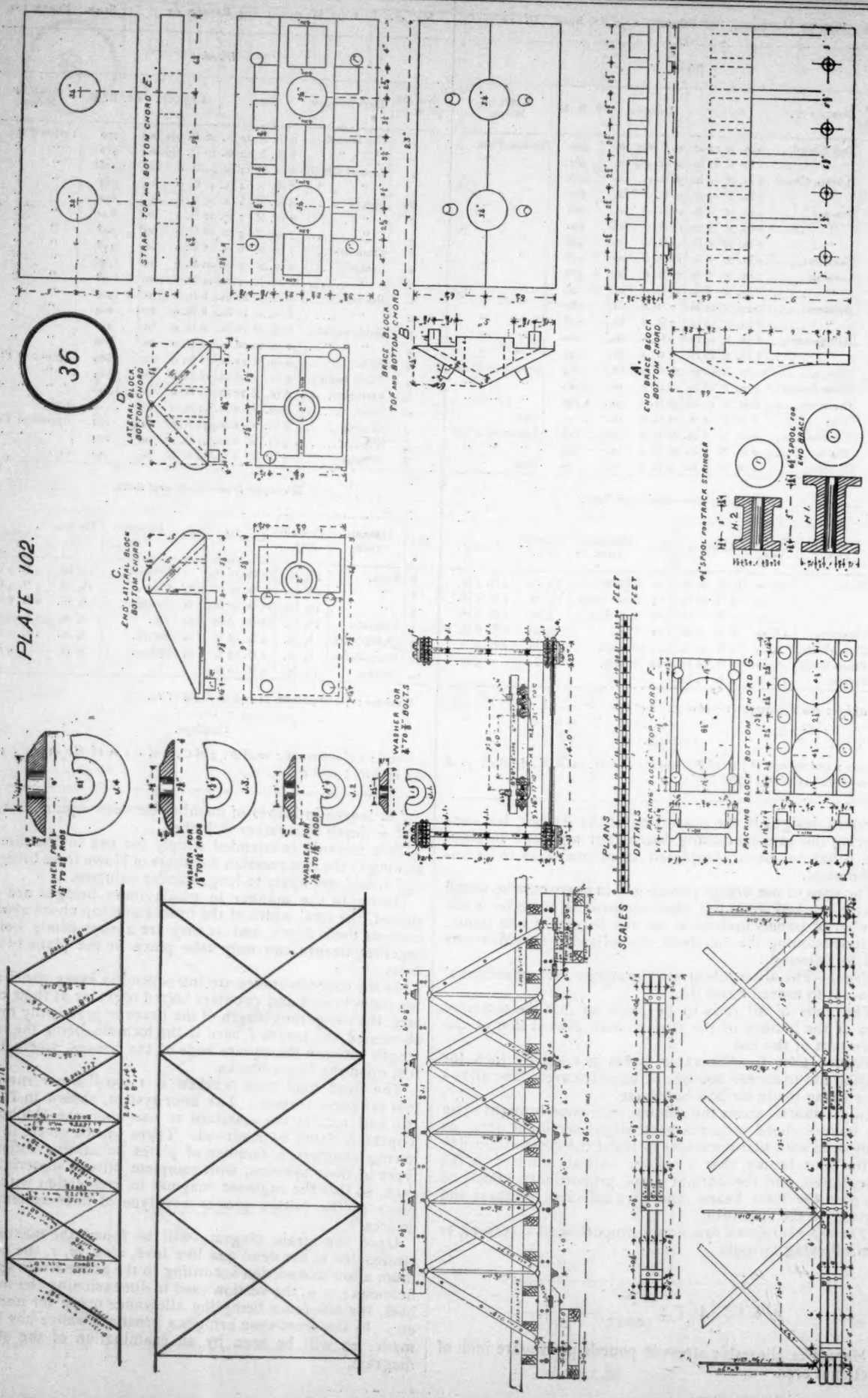
This formula is intended simply for use in the dimensioning of the compression members of Howe truss bridges, and would not apply to long, slender columns.

Owing to the manner in which these bridges are designed, the total width of the braces and top chord always exceeds their depth, and as they are always firmly bolted together flexure can only take place in the plane of the truss.

As the counter-braces are introduced in every panel and the main braces and counters bolted together at their centers, the dangerous length of the brace is practically much shortened, the length l, used in the formula, being the total length between the square ends of the braces, where they rest upon the brace-blocks.

The dead load used is taken at 1,500 lbs. per running foot for pony trusses. The floor system, shown in Plates 101 and 102, is the standard in use upon the Atchison, Topeka & Santa Fé Railroad. There will be given, in following chapters, a number of plates containing different types of floor systems, with complete bills of material for each, so that the engineer may use in connection with the plans of the bridge proper any type of floor system he desires.

Upon the strain diagram will be found the maximum strains due to the dead and live load, also, m, s, the minimum allowable section according to the above strain specifications; s, u, the section used in dimensioning the members, the difference being the allowance made for impact, etc. In the short-span bridges a great allowance has been made, as will be seen by an examination of the strain diagram.


36
PLATE 102.
STRAP TOP AND BOTTOM CHORD E.
BRACE BLOCK TOP AND BOTTOM CHORD B.
A. END BRACE BLOCK BOTTOM CHORD
D. LATERAL BLOCK BOTTOM CHORD
C. END LATERAL BLOCK BOTTOM CHORD
H 2
H 1
WASHER FOR 1" TO 1¼" RODS
WASHER FOR 7/8" TO 1" RODS
WASHER FOR 3/4" TO 7/8" RODS
WASHER FOR 1" TO 1¼" BOLTS
PACKING BLOCK TOP CHORD F.
PACKING BLOCK BOTTOM CHORD G.
PLANS
DETAILS
SCALES
FEET
FEET

The actual strains coming upon the top and bottom chords from compression and tension alone are so slight in these short-span bridges, as compared with the sectional area necessary for stiffness and cross-strain, that they have been omitted upon the strain diagram ; also, for the same reason, the strains upon the counter-braces and the strains upon the lateral bracing.

This series of bridge plans will include spans from 30 ft. to 150 ft., varying in length by 5 ft. or 6 ft. ; also, both deck and through bridges, with complete bills of material.

Each plan will be complete in itself, including every detail necessary for the construction of the bridge. This has led to the repetition of the drawings of some of the castings and details, but the Author considers that the advantage derived from having each separate bridge plan complete in itself, without the necessity of referring to any plan other than the particular one used, will more than counterbalance the extra amount of labor and expense in their preparation.

The graphical and analytical methods used in the calculation of the strain diagrams will be given in full.

Any engineer finding errors in these plans or bills of material, or having any suggestions to offer that will in any way increase their value to the engineering profession, will confer a great favor upon the Author by communicating at once with this Journal.

NOTE.

In regard to the plans of Overhead Crossings for Highways, which were left in a most incomplete condition in the February number, the Author begs leave to state that he was unable to procure some standard plans of such bridges in time to have them reproduced for this number ; but that later a full series of these plans will be given.

(TO BE CONTINUED.)

THE ESSENTIALS OF MECHANICAL DRAWING

By M. N. Forney.

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INTRODUCTION.

Some extenuating reason is demanded for writing another series of articles on Mechanical Drawing after the many which have already appeared, and in addition to all the books on the subject which have been published. This reason is that it has seemed to the writer that, in all of the books which have come under his observation, the subject has been made more difficult for the learner—especially if he is a person of limited education—than there is any need for. Many of them give examples and problems so difficult that all but the most indefatigable learners become discouraged. Most of these problems are of little practical value to a mechanic or draftsman and there is very seldom any occasion to make use of them. Take, as an example, the drawing of a projection of a screw-thread. Nearly all the books on mechanical drawing explain how this is done, and very often in an early chapter. In the first part of one of the books of this kind it is explained how to draw a pair of miter or bevel wheels *in an oblique position*—one of the most difficult problems of mechanical drawing that could be propounded, and one which few draftsmen ever have occasion to work out. Now it is admitted that an accomplished and thoroughly educated mechanical engineer and draftsman should have a knowledge of these and even of more difficult branches of his art, but they should be reserved for a later period, and should not form a part of elementary instruction to those who, in the beginning, want to learn only the Essentials of Drawing. In the following articles it will be the aim of the writer to explain these *Essentials* as simply and clearly as possible, and in the first part of the book all difficult problems which have no application in making or understanding ordinary mechanical drawings will be omitted.

In the interesting autobiography of James Nasmyth, the inventor of the steam hammer, that distinguished engineer says : "Mechanical drawing is the alphabet of the engineer. Without this the workman is merely 'a hand.' With it he indicates the possession of 'a head.' . . . Throughout my professional life I have found this art to be of the utmost practical value." Drawing, he says, is "graphic eloquence," and "is one of the highest gifts in conveying clear and correct ideas as to the forms of objects, whether they be those of a simple and familiar kind or of some mechanical construction."

The writer's experience, and the testimony of mechanics and engineers of distinction, confirms the opinion of Mr. Nasmyth that "*graphic language is one of the most valuable gifts which a man who has to do with practical subjects can possess.*" It is also true that an amount of instruction just sufficient to enable mechanics to understand, or, as they express it, "read" drawings, will be of great service to them, and will increase their usefulness to their employers. Even to persons who are not engaged in mechanical pursuits, a knowledge of the elements of mechanical drawing would be of more value than any other one thing, which can be learned so easily. Every farmer, at some time, has occasion to make a plot of a piece of land, a plan for a barn or pig-sty ; a merchant must lay out shelving for his shop ; a clergyman would like to plan a church, design a bookcase or a tombstone, or his wife will want to send the dimensions and shape of her parlor for a new carpet.

The aim of the following articles will be to make the study of mechanical drawing easy, so that its *essentials* can be comprehended by all who can read and write and cipher.

CHAPTER I.

To begin the study of Mechanical Drawing the learner should provide himself with the following instruments and materials :

Drawing Board.
T-Square.
Triangle with 30, 60 and 90-degree angles.
Triangle with 45, 45 and 90-degree angles.
Two-foot Rule.
Drawing Scale.
Protractor.
Joint Compasses.
Spring Compasses.
Point, Pencil-holder and Pen for the Compasses.
Pen-holder.
Half-dozen Drawing Tacks.
Half-dozen Sheets of Paper.
H H H H H H Pencil.
Piece of Fine Sand-paper.
Stick of India Ink.
Piece of India Rubber.

THE DRAWING BOARD.

The most suitable sized board, for a learner, is 32½ in. long and 21½ in. wide, for the reason that the paper best suited for his use is made in sheets 32 by 21 in., and when these are fastened to the board there should be a little margin outside of the edges of the paper. Such a board ought to be made of white pine "stuff" 1¼ in. thick, planed down to whatever thickness it will "go" when it is "trued up." The lumber which is used should be well seasoned "clear" or free from knots and resinous sap. There should be a cleat at each end of the same thickness as the board and 1½ in. wide, tongued and grooved, and nailed to the ends of the board with wire nails about 3¼ in. long, as shown in figs. 1 and 2. The nails should be driven in until their heads are about ⅛ in. below the surfaces of the cleats, and the holes should be puttied up. If the board is made of more than one piece the edges should be glued together, but the tongues and grooves for the cleats should not be glued. If they are the board is liable to split if it shrinks. A board made in this way can be smoothed off on both sides, so that either or both can be used for drawing on, which is often a convenience. If a smaller sized board is used it will not have weight enough to hold its position. There is, however, no special advantage in the particular size given. Almost any sized board will answer for a student who is eager to learn.

The ends of the board should be made straight and true. It is preferable to have them slightly concave rather than convex or "rounding." The long edges should be as near square with the ends as they can conveniently be made. Great accuracy in this respect is not essential, as the T-square should not be used on more than one edge of the board in drawing.

T-SQUARE.

The T-square should have a blade 35 in. long, about 2½ in. wide, and $\frac{3}{32}$ in. thick. The best ones are made of mahogany with ebony edges, but cherry, apple or pear wood, either with or without ebony edges, all answer very well for T-squares, straight edges and triangles. The head or stock of the T-square may be made of mahogany or any of the other woods mentioned. It ought to be $\frac{7}{8}$ in. thick, 10 in. long by 2½ in. wide at its greatest breadth, and of the shape shown in fig. 3. The blade

is fastened on the head (not let in) with screws and washers under them. If the blade is let into the head, so as to be flush with its surface, the head will project above the surface of the board when the T-square is in use, and will be in the way in using a scale or triangle near the left-hand edge of the board.

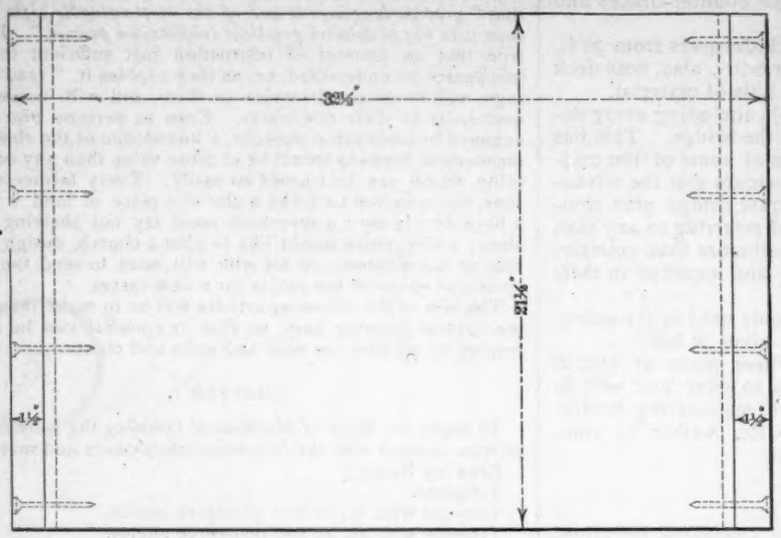


Fig. 1.

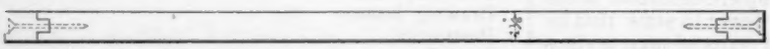


Fig. 2.

The copper washers which are made for leather machine belt rivets answer very well for fastening the blade of a square to its head.

The upper edge of the blade—which is the one used in drawing—should be at an equal distance from the two ends of the head when they are fastened together, as shown in fig. 3. The usual practice is to attach the blade to the middle of the head.

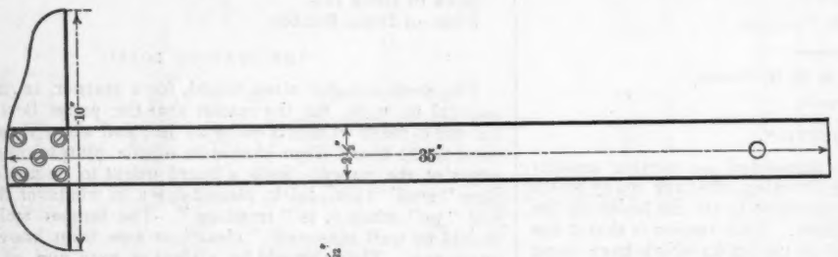


Fig. 3.

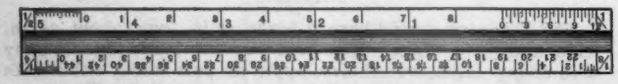
Fig. 4.

The objection to this is that when the blade is used near the lower edge of the board, the lower part of the head then projects so far beyond it as to be in the way of the elbow of the draftsman.

TRIANGLES.

The best triangles are made like those shown in figs. 5 and 6, of any of the woods named above for T-squares, and with ebony edges, but the latter is not essential. Very good ones without ebony edges, made of pear or apple wood, can be bought of the dealers in drawing materials, and still cheaper ones are made of one piece of wood with a round hole bored in the middle. These are not quite as satisfactory as the others, but very good work can be done with them.

The most convenient forms and sizes of triangles are those shown in figs. 5 and 6. One of them, fig. 5, should have 30, 60 and 90-degree angles with an 8-in. base; the other, fig. 6, should have 45, 45 and 90-degree angles and 4-in. base. They



should both be $\frac{3}{32}$ in. thick. The thickness is a matter of some importance; if they are either too thin or too thick they are inconvenient to work with. The reasons why these angles are preferable to any other will appear further on.

If the necessity for close economy is imposed upon the learner, he can make his own drawing board, T-square, and triangles, if he is a mechanic, or have them made, if he can obtain the services of any kind of a carpenter who is a good workman. To enable him to do this, the following method of laying off a 30, 60 and 90-degree triangle is given: Draw a circle *a b c d e f*, fig. 5. Then subdivide this circle by its radius into six equal divisions, and draw a line through the center of the circle, and two opposite points of division, *e* and *b*. From one of these points, *b*, draw a line to the next adjoining point, *c*, and then connect the latter with a line drawn to *e*, the point of beginning. Those lines will form the sides of the triangle with the required angles.

To make a triangle with two angles of 45 degrees, draw a circle *a b c d*, fig. 6, and a diameter *a c*. Then subdivide the semicircle *a b c* at *b*, and connect *a* and *b* and *b* and *c*. The triangle *a b c* will then have the required angles.

SCALES.

A 6 or 12-in. triangular boxwood scale, represented in fig. 7, is perhaps the best for a learner. They have two different scales on each edge, so that there are 12 altogether. For mechanical drawing they are usually graduated to $\frac{1}{10}$, $\frac{1}{8}$, $\frac{1}{6}$, $\frac{1}{4}$, $\frac{1}{3}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{3}{4}$, 1, 1½, and 3 in. = 1 foot. In addition to this scale a two-foot rule will be needed to make measurements and drawings full size. Any ordinary form will answer, but what is called an "engineer's pocket rule," fig. 8, is lighter and more convenient than the ordinary kinds.

PROTRACTOR.

A paper protractor like that represented in fig. 9 will be all that a beginner will need. These are printed on stiff paper or cardboard. In fact, the engraving will be all that the student needs in beginning his studies.

COMPASSES.

A pair of from 4 to 6 in. joint-compasses, similar to that shown by fig. 10, will be needed with a removable point, pencil-holder and pen for drawing circles or parts of circles with radii of from about ¼ in. up to 8 or 10 in. For small circles, a spring-compass, similar to that shown in fig. 11, should be provided. These engravings represent compasses designed by the writer. The point *c*, pencil-holder *d*,

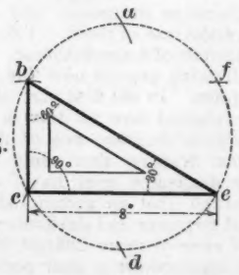


Fig. 5.

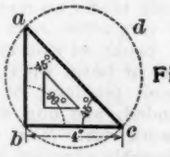


Fig. 6.

and pen *e* are made so that they can be used in either instrument, and also in the beam-compasses shown in fig. 19. The distance from the joints at *a* and the points at *b* are made shorter than usual, so that a larger circle can be drawn with compasses of a given size than is possible with those ordinarily sold. A pen-holder, fig. 12, is also provided, so that the pencil-holder and pen can each be used for drawing straight lines. This is often a convenience, especially with the pen when it is supplied with ink. As shown in the engravings, it can be quickly taken from the compasses and attached to the holder, fig. 12, without re-

Fig. 7.

moving the ink, and can thus be used for drawing either circles or straight lines. When a separate pen must be used for the compasses in drawing circles or curved lines, and another for drawing straight lines, in changing from one to the other the pen in use must always be cleaned and the other supplied with ink, which consumes valuable time.

The joint-compasses has a needle point at *b* to prevent the point from making a large hole in the paper, when many circles

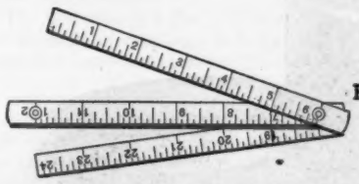


Fig. 8.

Fig. 13.

or curved lines must be drawn from one center. As the spring-compasses is smaller and lighter and is used only for small circles, it is not liable to enlarge the centers, and therefore does not require a needle point. Both the joint and spring-compasses can be used as dividers by substituting the point *c* in place of the pencil-holder or pen.

A great variety of forms and qualities of drawing instruments are sold by dealers. If the learner can possibly afford it, he is advised to buy only the best quality. If properly taken care of they will last him a lifetime. The aim in designing the instruments illustrated was to make as few as possible answer the requirements of a student or draftsman. The joint-compasses should be made of German silver, and the handle *f*, fig. 11, of the spring-compasses, and *g*, fig. 12, for the pen, of ivory.

DRAWING TACKS.

Fig. 13 represents two full-size views of a suitable size of drawing tack for holding the paper on the board. The points should be only about $\frac{1}{32}$ in. long and about $\frac{3}{100}$ in. in diameter, or about as large as an ordinary toilette pin. If drawing tacks are too big they are hard to press into the board and difficult to pull out. Generally the shanks or parts which enter the board are made so large in diameter that they leave very annoying holes. The shanks of the best tacks are screwed into the heads, which are made of German silver. If the shanks are merely riveted in the heads, they are apt to get loose in the act of pressing them into the board, with the result that one end of the shank enters the board and the other the operator's thumb.

PAPER.

A great variety of papers for various kinds of drawing can now be obtained of dealers from whom and from a little experience the draftsman will learn more than could be taught him by the writer. The learner is advised to get a half dozen or more sheets of what is known as linen record paper, which are made 21 by 32 in. in size. This paper is not costly, does not tear easily, it takes both pen and pencil-lines readily, and will stand a reasonable amount of abrasion from india-rubber. It is not very well suited for coloring with a brush, for which a different kind of paper should be used, as will be explained hereafter. Almost any kind of paper can, however, be used to draw on. A smooth pine board will do if nothing better can be obtained.

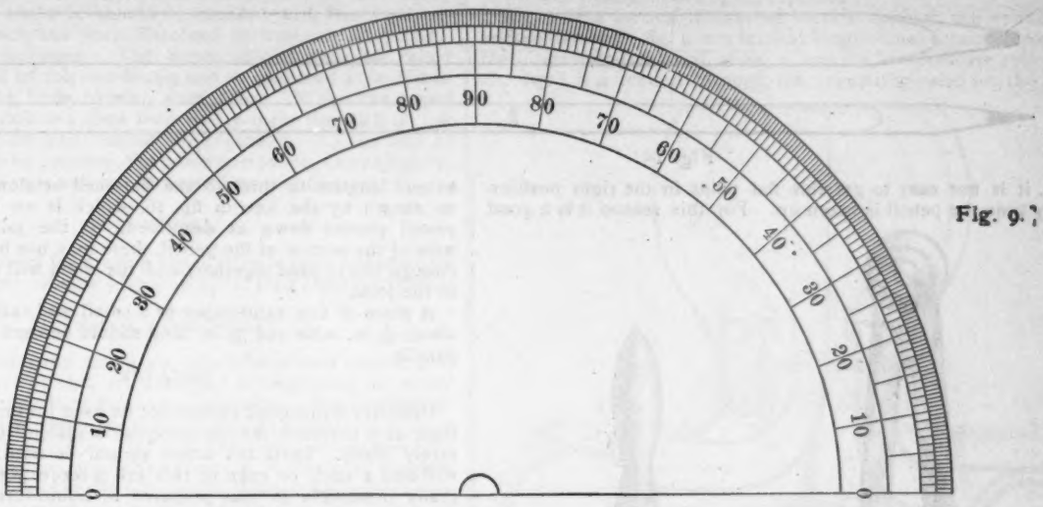


Fig. 9.

PENCIL.

Both Dixon's American Graphite or Faber's HHHHHH hexagon pencils are very good.

It is of the utmost importance in mechanical drawing that the representations of the objects should be accurate and precise, and therefore pencil lines should be drawn fine and distinct. For this reason hard pencils must be used, which will retain a sharp point longer than soft ones will. Both Dixon's

Fig. 10.

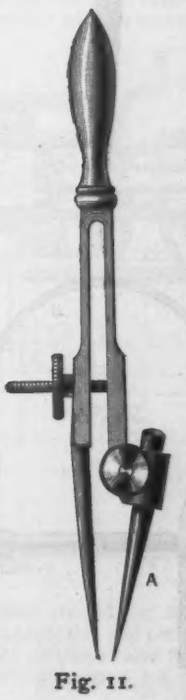


Fig. 11.

Fig. 12.

American Graphite and Faber's HHHHHH hexagon pencils are of about the requisite hardness.

In order to maintain a sharp pencil point as long as possible, it should be made flat, so as to be long in the direction in which it is moved and worn, and therefore the point should be sharp-

ened to a form somewhat like a chisel edge rounded, as shown at *a* and *b* in figs. 14 and 15. If the pencil is round or octagonal, it is not easy to get this flat point in the right position every time the pencil is taken up. For this reason it is a good plan to have the wood of the pencil planed down so that it will be flat, as shown in figs. 14, 15 and 16. In doing this care should be taken that the wood is planed away on each side of the edges which are glued together, and that the glued joint should extend lengthwise through the flattened section of the pencil, as shown by the line in fig. 16, which is an end view of a pencil planed down as described. If the joint runs crosswise of the section of the pencil, there may not be glued surface enough left to hold together, and the wood will then split apart in the joint.

Fig. 14.

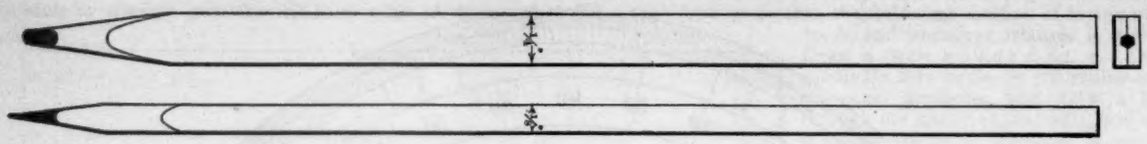


Fig. 15.

Fig. 16.

Fig. 17.

Fig. 18.

A piece of fine sand-paper or a small and rather fine flat file about $\frac{5}{16}$ in. wide and $3\frac{1}{2}$ in. long should be used for sharpening pencils.

INDIA INK.

Ordinary writing ink should not be used for mechanical drawings, as it corrodes the instruments, is difficult to erase, and is rarely black. India ink alone should be used. The student will find a stick or cake of this ink is more portable and generally preferable to that prepared in liquid form. There is a great difference both in price and in quality of the various kinds of India ink. It consists essentially of lamp-black in *very fine condition*, baked up with a glutinous substance. If the lamp-black has not been reduced to a very fine condition, or if there is any gritty substance in it, the ink will not flow freely from the pen. Various tests for this ink have been given in different books, but probably the best the student can do is to buy a stick and try it, and if it is not good try some other kind. India ink is liable to crack in drying after it has been wet, or from exposure

Fig. 20.

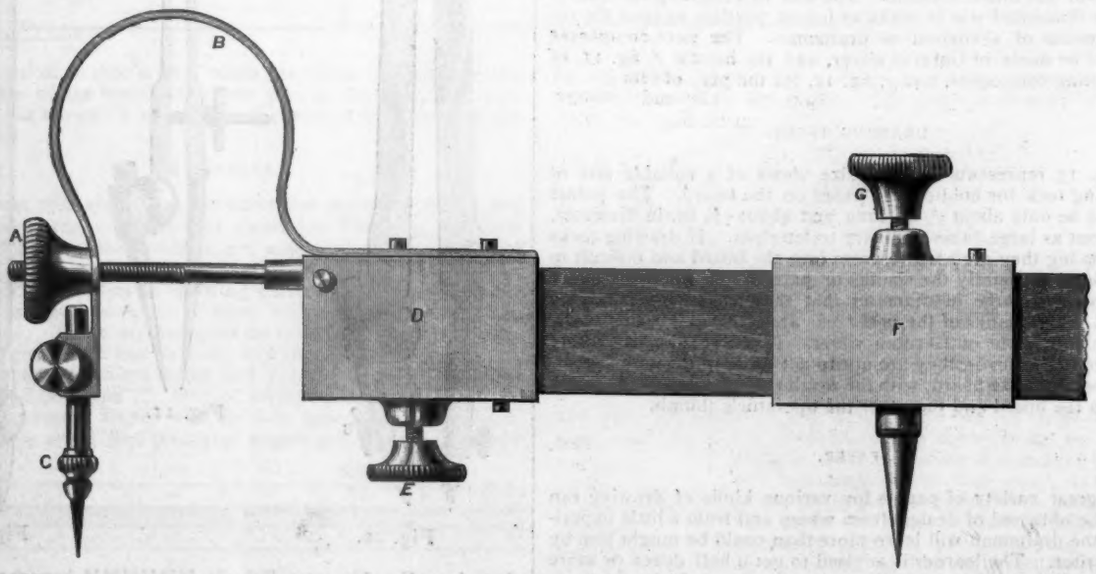


Fig. 19.

to the air. For this reason a round stick is the most convenient form. This can be protected from the air by cutting a piece of thick and strong manilla paper of the right size to roll around the stick of ink twice. The paper should first be thoroughly moistened and one side should be covered with liquid glue or gum-arabic, which has been dissolved in water to the consistency of thick molasses. The paper should then be rolled around the stick of ink and thus glued or gummed to it and to itself, where the folds overlap each other. When the paper dries it will shrink and thus hold and protect the stick of ink from moisture, air and liability to breakage. As the end of the stick is worn by rubbing, the paper can be cut away slightly, so that particles of it will not be rubbed up with the ink.

INDIA RUBBER.

The best material for erasing pencil lines is what is known as "velvet" rubber. Pieces ½ by ½ by 2½ in. long are a convenient size.

ADDITIONAL INSTRUMENTS.

The instruments and materials which have been enumerated and described are all that are essential in beginning the study and, in fact, in practising mechanical drawing. There are, however, some others which the student would do well to get if he can conveniently afford it. He will find that considerable time will be lost and some annoyance incurred in changing the pencil-holders and points in the compasses, if these instruments are used both for drawing circles and as dividers for laying off dimensions. For this reason he will find that a pair of

JOINT AND SPRING DIVIDERS,

shown in figs. 17 and 18, will make frequent changes of the point and pencil-holder unnecessary, and will therefore be a great convenience.

He will also find that it is sometimes essential to draw circles or parts of circles with a larger radius than he can command with his joint-compasses. To meet this requirement a

BEAM-COMPASSES

will be needed. The one shown in fig. 19 has also been designed by the writer, and is arranged to take the same point, pencil-holder and pen that is used with the joint and spring compasses, figs. 10 and 11. The beam-compasses cansist ot a permanent head *A*, which is fastened to the wooden bar or stick *W* by the set screw *E*. The spring *B* is fastened to the head *A*, and has a socket at *S''* to receive the pencil-holder and pen. The wooden bar *W* can be made of any length required within obvious limits. The movable head *F* has a point *E*, and slides on the bar *W*, and can be clamped by the screw *G* in any desired position, and the distance between the point *E* and the pen or pencil at *F* can be made whatever is needed. It is not easy, however, to regulate this distance with great precision by the screw *D* alone. For this reason the spring is arranged with a screw and nut *A*, by means of which the position of the pen or pencil can be adjusted with great accuracy. Wooden bars of different lengths can be provided, so that curves of any radii up to obvious limits can thus be drawn.

INK CUPS.

A nest of cups or "cabinet saucers," fig. 20, are also very convenient for rubbing ink and colors in, the use of which will be explained further. Those 2½ in. outside diameter are a convenient size.

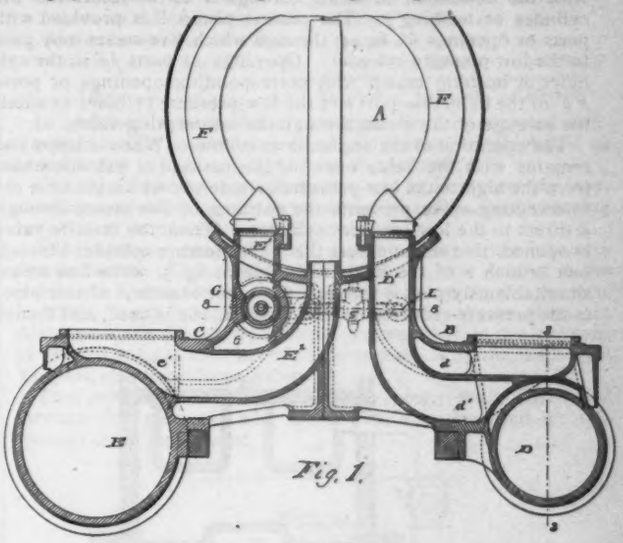
(TO BE CONTINUED.)

Recent Patents.

I.—PITKIN'S COMPOUND LOCOMOTIVE.

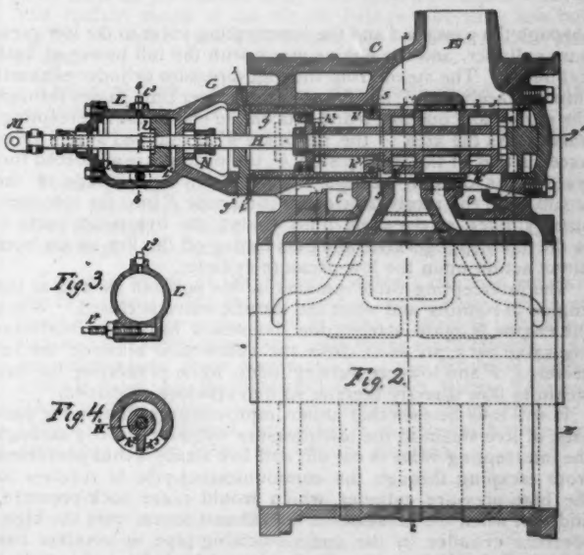
MR. A. J. PITKIN, Superintendent of the Schenectady Locomotive Works, has patented an improvement in compound locomotives, the object of which is first, to regulate automatically the admission of live steam to the low-pressure cylinder in starting; and, secondly, automatically to cut off the passage of live steam to the low-pressure cylinder by the action of the exhaust-steam from the high-pressure cylinder upon an intercepting-valve between the high and low-pressure cylinders. This valve is opened automatically for the passage of live steam direct to the low-pressure cylinder to start the engine, and after the engine is started the valve is closed by the pressure of the exhaust-steam from the high-pressure cylinder. The direct access of live steam to the low-pressure cylinder is thus cut off by the action of the intercepting-valve, and, when the throttle-valve is closed, the intercepting-valve remains closed until live steam is again admitted to the high-pressure, when the operations which have been described are again repeated.

Fig. 1 is a vertical transverse section through the cylinders and smoke-box; fig. 2 is a vertical longitudinal section through the intercepting-valve *G*, of fig. 1, and the low-pressure cylinder *E*; fig. 3 is a section through the regulating-valve on the line



6 6 of fig. 2, and fig. 4 a similar section through the regulating-valve on the line 5 5; and fig. 8 is a horizontal section through the intercepting valve and saddles on the line 8 8 of fig. 1.

The engine has two cylinders located in the usual way. *D*, fig. 1, is the high-pressure and *E* the low-pressure cylinder. The saddles *B C* are also constructed in a similar way to the ordinary practice, and have the usual induction and eduction-ports. The exhaust-port d', of the high-pressure cylinder, is connected by a pipe or conduit *D'* with an arched or horseshoe-



shaped pipe *F F*, which passes around the smoke-box in the ordinary way, and forms a superheater and receiver, and is connected with the pipe *E'*, which communicates through the intercepting-valve *G* with the induction-ports *e e*, figs. 1 and 2, of the low-pressure cylinder.

The intercepting-valve *G* is of the piston type and is contained in a chamber cast in the saddle *C*. This has a bushing *g*, fig. 2, and two removable heads g^1 and g^2. Another cylindrical chamber *L* is attached to the head g^2, and a piston-rod *H* works through a stuffing-box *N* and carries four pistons *h h' h²* and *l*. The pistons *h* and *h'* are separated a sufficient distance for the passage of steam between them, from the pipe *E'* to the induction-ports *e e* which supply the low-pressure cylinder with steam. The piston h^2 is nearer the other or forward end of the valve-cylinder *g*, and is of smaller diameter than the others, the bore of the cylinder being reduced in that portion traversed by this

piston, in order that the other pistons may exert a preponderating pressure on the intercepting-valve at the proper time, as hereinafter explained. This part of the cylinder is provided with a live-steam induction-port *i*, and also with an eduction-port *i'*, opening direct to the atmosphere for the escape of the steam or condensed water from this portion of the cylinder. The piston h^2 is far enough from the piston *h'* not to interfere with the admission of steam through *h'* to the interior of the cylinder or bushing *g*. The central piston *h'* is provided with ports or openings h^3, fig. 4, through which live steam may pass to the low-pressure cylinder. Openings or ports *j j'* in the cylinder or bushing match with corresponding openings or ports *k k'* in the induction-port *e* of the low-pressure cylinder to admit the passage of the steam through the intercepting-valve.

The operation of the engine is as follows: When it stops and remains with the valve open for the passage of exhaust-steam from the high to the low-pressure cylinder, in which position the intercepting-valve prevents the entrance of live steam through it direct to the low-pressure cylinder. When the throttle-valve is opened, live steam enters the high-pressure cylinder through one branch *s* of the live-steam pipe *S*, fig. 5, while live steam simultaneously passes through the other branch *s'* of this pipe, to the pressure-reducing device *S'*, when one is used, and thence

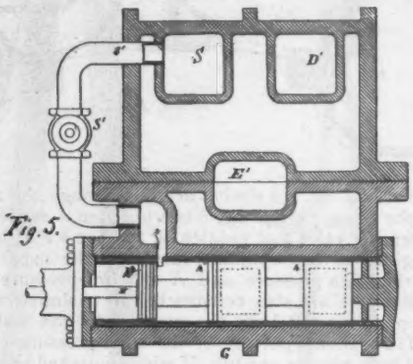


Fig. 5.

through the passage *i* and the intercepting-valve to the low-pressure cylinder, and the engine starts with the full power of both cylinders. The steam from the high-pressure cylinder exhausts into the receiver *F F*, fig. 1, and at the proper time passes through the port *h'* and opening *e* and acts on the end of the intercepting-valve. As the area of the pistons *h h'* at that end of this valve exceeds that of the front piston h^2, the pistons are all forced forward, thus opening the ports *j j' k k'* for the passage of the steam from the receiver or connecting-pipe *F* into the low-pressure cylinder, at the same time closing the live-steam ports h^3 in the intercepting-valve, and thus cutting off the live steam from direct action upon the low-pressure cylinder.

The intercepting-valve remains in this position as long as the engine is running and when the throttle-valve is closed. When the engine is again started, the live steam forces the intercepting-valve back, so as to close the connection between the receiver *F F* and low-pressure cylinder, while permitting the live steam to flow directly therein, as hereinbefore explained.

It will thus be seen that under improved organization the passage of live steam to the low-pressure cylinder directly through the intercepting-valve is cut off, and live steam is thus prevented from escaping through the communicating-pipe or receiver to the high-pressure cylinder, which would cause back-pressure, and that when the pressure of the exhaust-steam from the high-pressure cylinder in the communicating-pipe or receiver has risen sufficiently it automatically closes the intercepting-valve, and thus cuts off the live steam from direct access to the low-pressure cylinder, simultaneously opening the port for the passage of the steam from the high to the low-pressure cylinder, all these motions being automatic.

In order to regulate the movements of the intercepting-valve and to prevent any sudden backward and forward action, as would occur were the steam turned on without some compensating device, the piston-rod *H* is prolonged through suitable glands in the valve-chamber *L*, in which a piston *l* slides. Ports l^1 l^2 connect the opposite ends of this chamber, which is filled with oil or some analogous fluid through an opening l^3.

The area of the passage connecting the parts l^1 l^2 may be varied by a transverse screw l^4, fig. 3, so as to control the rapidity of the flow of fluid from one side of the piston to the other, and the consequent rapidity of the movement of the intercepting-valve.

Manufactures.

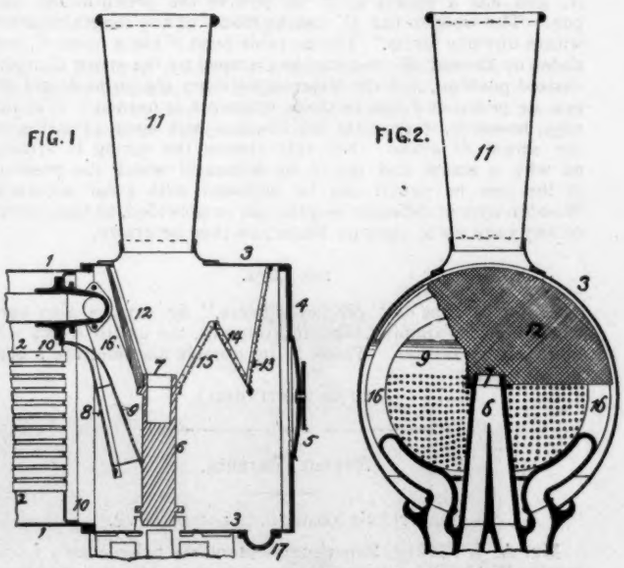
Bell's Spark Arrester.

THE accompanying illustrations show an improved spark arrester, invented by Mr. J. Snowden Bell, of Pittsburgh, an application for a patent for which is now pending. The object of this invention is to present an area of screen surface sufficient for the effective separation of the solid matters, which may be drawn through the tubes, from the gaseous products of consumption, without impairing the proper draft on the fire or requiring the use of the heavy and costly extended smoke-box.

In the accompanying illustration, fig. 1 shows a longitudinal section of a locomotive smoke-box provided with the improvement, and fig. 2 a cross-section of the same. The construction of the extended smoke-box, with its system of deflectors, is generally understood, and the differences will be readily seen from the engraving and from the description below.

The improvement, as shown, is applied in a locomotive boiler of the ordinary standard construction with tubes 2 2 extending through the shell or barrel 1 1 from the fire-box to the tube-sheet 10, and delivering the products of combustion into the smoke-box 3, which is closed at its forward end by the front 4, having a suitable door, 5, and provided with an open smoke-stack, 11. A deflector or check-plate, 8, secured at the top to the tube-sheet 10, and inclined forward and downward to a proper level is used, but instead of making the same a plain plate it is in this construction, from a level somewhat below the upper row of tubes, grated or perforated with a series of openings of ½ in. or more in diameter, and a supplemental deflector, 9, also inclined downward and forward, is secured to the sheet at or near the line of attachment of the first deflector 8. The openings in this second deflector 9 are smaller in diameter than those in the plate 8, and the upper row of perforations is also at a lower level than the corresponding row in the deflector 8; but if deemed desirable, they may be wholly or partially dispensed with, and the whole or part of the deflector 9 be formed of the plain plate 8. The object of this perforated plate is to disintegrate and extinguish large pieces of unconsumed fuel which may be drawn through the tubes, and thus to prevent the throwing of live coals from the stack.

In connection with these deflectors suitable screens or netting may be used between the exhaust-pipe and the stack. A construction preferred by the inventor is shown in the drawings, and consists of a connected series of inclined transverse screens



or nettings 12, 13, 14, and 15, which may be either of wire netting or perforated metal. The screens 12 and 13 are of segmental form, and 14 and 15 are of zone form, the screen 12 being placed between the steam-pipe 16 and exhaust-pipe 6, in rear of the stack opening, as shown and extending downwardly to the top of the exhaust-pipe, while 13 is placed a short distance from the front ring of the smoke-box inclined backward and extending backward to the same level as 12. The screens 14 and 15 are connected at the top and inclined in A form, 14 being connected at the bottom to 13, and 15 extending to the top and front of the exhaust-pipe. The screens 12 and 15 are separated at the bottom by a space equal to the diameter of the exhaust-

pipe, this space being bridged on each side of the exhaust-pipe by a suitable connecting piece, which may be either perforated or plain. The outer surfaces of all the screen sections conform to the curvature of the smoke-box, and are connected thereto by angle irons in the usual manner, as shown in the drawings. While the segmental screen shown as a partition in rear of the exhaust-pipe is preferred, it is not essential to the improvement, and any other suitable partition, either perforated or plain, may be substituted for it.

The smoke-box projects in front of the cylinder saddle only enough to permit of the attachment of the cinder discharge 17. This may be simply a hole with a suitable cap or cover, or where the fuel used is such as to render a spark receptacle desirable, a separate chamber may be connected without any change in the other arrangements.

It will be seen that by this construction a material increase of screen area is attained without increasing the length of the smoke-box, and there being no horizontal portion except the narrow connecting piece uniting the screens 12 and 15 at the bottom, nearly all of this area is presented in an inclined position, which, it is claimed, more effectually resists the tendency of solid matter to pass through the screens, and renders a larger mesh or perforations admissible. In this way the advantages claimed for the extended smoke-box are secured without the accompanying drawbacks.

Anthracite Coal Production.

THE official report of the production of anthracite coal for the year ending December 31, is as follows:

	1889.		1888.	
	Tons.	Per ct.	Tons.	Per ct.
Wyoming Region	18,647,925	52.7	21,852,366	57.3
Lehigh Region	6,285,421	17.7	5,639,236	14.8
Schuylkill Region	10,474,364	29.6	10,654,116	27.9
Total	35,407,710	100.0	38,145,718	100.0

The decrease last year from 1888 was 2,738,007 tons, or 7.2 per cent. In addition the stock of coal on hand at tidewater points—1,026,107 tons on December 31 last—showed an increase of 373,951 tons.

Eastern competitive tonnage—which includes all anthracite coal which, for final consumption or in transit, reaches any point on the Hudson River or the Bay of New York, or which passes out of the Capes of the Delaware—was 12,217,862 tons last year; a decrease of 1,439,742 tons, or 10.5 per cent., from the previous year.

Locomotives.

THE Brooks Locomotive Works, Dunkirk, N. Y., have an order for 10 heavy passenger engines for the Wisconsin Central Railroad.

THE Rogers Locomotive Works, Paterson, N. J., recently delivered two passenger and 10 mogul freight engines to the Georgia Pacific Railroad. The same works have an order for 10 consolidation freight engines and 10 heavy switching engines for the Louisville & Nashville Railroad.

THE Dickson Manufacturing Company, Scranton, Pa., has an order for 25 locomotives for the New York, Ontario & Western Railroad branch to Scranton.

THE Schenectady Locomotive Works, Schenectady, N. Y. recently delivered a passenger engine with 17 × 24 in. cylinders, and a 12-wheel freight engine with 20 × 26 in. cylinders to the Beech Creek Railroad.

THE Baldwin Locomotive Works are building a considerable number of locomotives for export. Many of these must be made in conformity with the specifications of English and European engineers, and in several cases the use of wrought-iron spoke-wheels for truck, driving, and tender-wheels has been insisted upon. The present condition of affairs in Europe is such that it is difficult to obtain railroad equipment or material of any character for reasonably early delivery. The Baldwin Works were therefore compelled either to decline orders offered or to find some means of furnishing wrought-iron wheels themselves. They have therefore undertaken to make these wheels so far as forced to by the requirements of the locomotive business. In doing this a system of manufacture was adopted which is novel, and is believed to have greater merit than any other now in use. There is no intention, however, of making wrought-iron wheels for any other purpose than that indicated above.

Iron Production.

THE American Iron & Steel Association reports that the production of pig iron in the United States for three years past has been, in net tons:

Fuel.	1889.	1888.	1887.
Bituminous	5,952,414	4,743,989	4,270,365
Anthracite and coke	1,575,996	1,648,214	1,919,640
Anthracite alone	344,358	277,575	418,749
Charcoal	644,300	598,789	578,182
Total	8,517,068	7,268,507	7,186,936

In addition to the increase in output there is reported a decrease in stocks on hand unsold of 58,760 tons, which should be added to the gain of 1,248,561 tons in production.

The chief increase in consumption was in Bessemer pig iron, showing once more a point heretofore referred to, the increasing use of steel in manufactures and construction.

The increase was pretty well distributed over the iron-producing States. The relative gain, however, was largest in the South, the figures for the Southern States being: 1,566,702 tons in 1889; 1,132,858 tons in 1888; 929,436 tons in 1887. In Alabama alone the pig iron output increased from 292,762 tons in 1887 to 791,425 tons in 1889; Tennessee, Virginia, and West Virginia also show large gains.

The production of last year was pretty well distributed through the year. It was the largest ever reported for this country for a single year.

Bridges.

THE contract for the Newtown Creek draw-bridge for the city of Brooklyn has been let to Dean & Westbrook. It is an 80-ft. counterbalanced draw-span.

THE Pencoyd bridge shops have been shipping material for the Union Elevated Railroad of Brooklyn, at the rate of 200 tons a day.

THE Rochester Bridge Works have the contract for a 120-ft. pony truss for the Kansas City, Fort Scott & Memphis Railroad. The Buffalo shops of the Union Bridge Company are building for the same road a 65-ft. and an 80-ft. steel plate girder bridge.

THE New York, Lake Erie & Western Railroad has made a permanent contract with the Union Bridge Company to build all its bridges. Considerable work is now in the shops at Athens.

THE Paterson Rolling Mill Company has the contract for a 150-ft. span, and several girder spans for the Chesapeake & Ohio Railroad. This Company is also building the extension of the Hudson County Elevated Railroad in Jersey City.

THE new shops of the Elmira Bridge Company are hardly yet in running order, though most of the machinery is in position and ready for work. The principal trouble is lack of material, which is also giving the Union shops much trouble. They are working on three contracts—viz., the Schuykill Viaduct, 1,200 ft. long, for the Schuykill & Lehigh Valley Railroad, a feeder of the Lehigh Valley; an 80-ft. plate girder span for the Lehigh Valley Railroad, and a 150-ft. double-track plate girder draw span for the New York Central Railroad.

OBITUARY.

WILLIAM H. TURNER died at his residence in New Rochelle, N. Y., January 31, aged 54 years. Mr. Turner was an old railroad man, having entered the office of the Norwich & Worcester Railroad when only 17 years old; after having served on that road as clerk and freight agent, he was for a time Superintendent of the Portland & Rochester Railroad, and later of the Boston & New York Air Line. More recently he was Superintendent of the Eastern Division of the New York & New England, and afterward General Superintendent of that road; for three years past he has been Superintendent of the New York Division of the New York, New Haven & Hartford Railroad.

DANIEL ADAMSON, who died in Manchester, England, January 13, was well known as one of the largest manufacturers of boilers and machinery in England. He was born in 1820, and

learned his trade under Mr. Hackworth in the Stockton & Darlington Railway shops. He was inclined to introduce new methods and make innovations to an extent somewhat unusual in England, and invented and patented a number of machine tools. He was one of the first projectors of the Manchester Ship Canal, and was mainly instrumental in the formation of a company for that enterprise.

WILLIAM JARVIS MCALPINE, who died at his residence at New Brighton, N. Y., February 16, aged 78 years, was one of the oldest and best known of American engineers. He was born in New York City, and when 15 years old began work in an engineer corps, learning his profession chiefly in the field and on canal work. His first prominent position was as Engineer in charge of the enlargement of the Eastern Division of the Erie Canal. In 1846 he was made Chief Engineer in charge of the building of the dry-docks at the Brooklyn Navy Yard, and was employed there for several years. In 1852 he was elected State Engineer of New York, and held office four years. Later he was Chief Engineer of the Erie Railroad for some time, and was also on several other prominent roads.

Among important works which Mr. McAlpine planned were the water-works of Chicago, Albany, and several other cities; several river improvements in this country, and the plans for the improvement of the Danube for the Austrian Government. For several years past he has retired from active work, but has been much employed as a consulting engineer on many important works, among them the State Capitol at Albany.

Mr. McAlpine had been for many years a member of the American Society of Civil Engineers; he was President of the Society in 1868–69, and was made an Honorary Member in 1888. To the last he took an active interest in his profession.

PERSONALS.

J. T. HARAHAN has resigned his position as General Manager of the Chesapeake & Ohio Railroad, which he has held since March last.

COLONEL J. W. ROBERTSON has been appointed a member of the Georgia Railroad Commission in place of Major Campbell Wallace, who has resigned.

G. T. JARVIS has been appointed Division Superintendent of the Baltimore & Ohio Railroad, with office at Newark, O., succeeding R. T. DEVRIES, who has resigned.

FREDERICK A. SCHEFFLER, recently Superintendent of the Erie City Iron Works, Erie, Pa., is now Acting General Superintendent of the Westinghouse Electric Company in Pittsburgh.

E. D. BRONNER has been appointed Master Car-Builder of the Michigan Central Railroad, succeeding Mr. ROBERT MILLER. Mr. Miller still remains Assistant General Superintendent of the road.

H. TANDY has resigned his office as Superintendent of Motive Power of the New York, Ontario & Western Railroad, to accept the position of Superintendent of the Brooks Locomotive Works at Dunkirk, N. Y.

COMMANDER WILLIAM M. FOLGER, U. S. N., has been appointed Chief of the Bureau of Ordnance in the Navy Department, with the rank of Commodore. This appointment has been expected for some time.

HARVEY MONKHOUSE has been appointed General Master Mechanic and Assistant General Master Car-Builder of the Chicago, Rock Island & Pacific Lines west of the Missouri River. His office is at Horton, Kan.

COLONEL C. W. RAYMOND, U. S. Engineers, has been relieved from duty as Engineer Commissioner of the District of Columbia, and will be assigned to other duty. He is succeeded by LIEUTENANT-COLONEL J. M. ROBERT, U. S. Engineers.

J. S. PATTERSON is appointed Master Mechanic of the Columbus, Hocking Valley & Toledo Railroad, and will have charge both of the motive power and car departments. He succeeds Mr. I. G. HUTCHINS, Master Mechanic, and J. M. ROCKAFIELD, Master Car-Builder, who have resigned.

GEORGE F. WILSON is appointed General Master Mechanic of the Chicago, Rock Island & Pacific Railway, and his jurisdiction will extend from the Company's lines both east and west of the Missouri River, with headquarters in Chicago. He succeeds Mr. T. B. TWOMBLY, who has resigned after many years' service on the road.

MAJOR CAMPBELL WALLACE has resigned his position on the Georgia Railroad Commission. He has been a member of the Commission since its first organization, and has taken a very active share in its work. Major Wallace is a practical railroad man of long experience, and has been a very useful officer. He is now 86 years old, and retires from active work altogether.

H. WALTER WEBB has been appointed Third Vice-President of the New York Central & Hudson River Railroad; this is a new office, and the holder will have general supervision of the Operating Department. Mr. Webb has been for some time Assistant to the President and also President of the Wagner Palace Car Company. At the same time General Superintendent JOHN M. TOUCEY was appointed General Manager, and Assistant General Superintendent Theodore Voorhees was made General Superintendent of the road.

PROCEEDINGS OF SOCIETIES.

American Society of Civil Engineers.—At the regular meeting, February 5, a paper was read by Mr. Cope Whitehouse on the Raiyan Canal and Storage Reservoir, Egypt.

The tellers announced elections as follows: *Fellow of the Society.*—V. M. Clement, of Idaho.

Members.—Oscar F. Balston, Brooklyn, N. Y.; George Codwise Dickinson, Fort Montgomery, N. Y.; Joseph Hobson, Hamilton, Can.; John Alexander McDonald, Sidney, N. S. W., Australia; Maurice Stiles Parker, Winona, Minn.; Edward Clapp Shankland, Pittsburgh, Pa.; William Henry Warren, Sidney, N. S. W., Australia; George Leverett Wilson, St. Paul, Minn.

Juniors.—Edward Hanson Connor, Buffalo, N. Y.; Amory Prescott Folwell, Glenns Falls, N. Y.; Edward Etienne de Lancey, Sing Sing, N. Y.; Hugo S. Speidel, Paterson, N. J.; John Frederick Temple, Edge Moor, Del.; Henry Grattan Tyrrell, Pencoyd, Pa.; Thomas Tainter Watson, Morristown, N. J.

American Geological Society.—The annual meeting of this Society was held in New York, beginning December 27 and ending December 29. There was a large attendance at the opening meeting, and after the usual preliminary addresses the reports of the Treasurer and Secretary were read and approved. The following officers were elected for the ensuing year: President, James D. Dana; Vice-Presidents, John S. Newberry and Alexander Winchell; Secretary, John J. Stevenson; Treasurer, Henry S. Williams; Executive Council, J. W. Powell, George M. Dawson, and Charles H. Hitchcock.

It was announced that 15 new Fellows had been elected. Announcement and comment was made on the deaths for the past year, which included Professor George H. Cook, David Honeyman, and Dr. C. A. Ashburner.

The remaining sessions were devoted entirely to the reading of papers, many of which were of an entirely technical character. Among those presenting papers were Professors T. H. Chamberlin, N. S. Shaler, Robert Bell, S. F. Emmons, George H. Williams, Charles D. Walcott, and others. Many of these papers called out considerable discussion from members present.

The Society was reported to be in a very flourishing condition, and much good work has been accomplished during the past year.

American Geographical Society.—At the annual meeting in New York, January 14, the following officers were elected: President, Charles P. Daly; Vice-President, Francis A. Stout; Secretary, James M. Bailey; Treasurer, Walter R. T. Jones; Councillors, William Remsen, John A. Hedden, Clarence King, Christian Börs, and Edward King.

The President then delivered his annual address, which was chiefly a review of the discoveries by excavations in Eastern countries of recent years and their relation to the history of man.

Master Mechanics' Association.—A number of circulars of inquiry have recently been sent out from the office of the Secretary, Mr. Angus Sinclair.

The Committee on Axles for Heavy Tenders asked for opinions on the best dimensions and form of such an axle, and on the limit of weight on journals per square inch of contact. The Chairman of this Committee is William Swanston, Master Mechanic of the Chicago, St. Louis & Pittsburgh Railroad, Indianapolis, Ind.

The Committee on the Advantages and Disadvantages of Placing the Fire-Box above the Frames request opinions and

experience on this subject; also information as to the form and depth of fire-box preferred, and as to any experience gained with either form. The Chairman of this Committee is Mr. F. B. Griffith, Master Mechanic of the Delaware, Lackawanna & Western Railroad of Buffalo, N. Y.

The Committee on Corrosion of Water Tanks request information on this subject, and also as to devices which may have been adopted to prevent it. The Chairman is Mr. W. J. Robertson, Superintendent of Motive Power of the Central Vermont Railroad, St. Albans, Vt.

The Committee on the Relative Value of Steel and Iron Axles request opinions as to the safe limit of diameter for driving-axles, truck-axles, and tender-axles for different weights on journals; also information as to the relative wear of steel and iron axle journals and bearings per 50,000 miles run, and as to endurance and comparative number of breakages of axles. The Chairman is Mr. John McKenzie, Superintendent Motive Power of the New York, Chicago & St. Louis Railroad, Cleveland, O.

The Committee on Efficiency of the Link Motion, as compared with other valve motions, asked for any information attainable on this subject, including results of tests, indicator diagrams, first cost and maintenance, etc. The Chairman is Mr. James M. Boone, Superintendent Motive Power, West Shore Railroad, Frankfort, N. Y.

The Secretary has also issued a circular urging upon members the necessity of answering questions as fully and as promptly as possible, in order to enable the Committees to do satisfactory work.

Master Car-Builders' Association.—The Executive Committee issued the following circular under date of December 24, 1889:

"Under the duties imposed upon the Executive Committee by By-Law No. 3, this Committee announces that it has selected Old Point Comfort, Va., as the place for holding the next Annual Convention of the Master Car-Builders' Association, commencing on Tuesday, June 10, 1890. The headquarters of the Association will be at the Hygeia Hotel, the management of which has named a uniform rate of $3 per day for all who attend the Convention. The Committee of Arrangements consists of Messrs. Wade, Day, and Demarest, but members who wish to engage rooms in advance should address Mr. F. N. Pike, Manager Hygeia Hotel, Fortress Monroe, Va.

"The Executive Committee regrets that Charleston, S. C., the place selected at the last Convention, is ineligible on account of insufficient hotel accommodations for a fairly well-attended Convention of the Association, because the Committee realizes that the well-known hospitality of Charleston would have insured a pleasant reception to the Association.

"The Committee also found Look-Out Mountain, near Chattanooga, Tenn., ineligible for the same reason; when the new hotel, now being built at this point, is completed, it will probably be capable of accommodating the Association, and although the management promises to have it opened in May, the Executive Committee thought it best to select a place where the necessary accommodations already exist.

"Buffalo, N. Y., was mentioned as one of the three places for the Executive Committee to consider, but the subsequent action of the Convention, restricting its choice to Charleston, and the manifest desire on the part of many members to go South in 1890, have led the Committee to disregard Buffalo, believing that by the selection as above announced it meets the wishes of a larger portion of the membership than could be done by the selection of any other place."

Canadian Society of Civil Engineers.—The fourth annual meeting was held in Montreal, January 23. The annual report showed that there are now 70 members of the Society. The President delivered his annual address, which related principally to the progress of engineering in Canada, and incidentally gave some account of the principal works now in progress. The Governor-General then made a short address.

The following officers were elected for the ensuing year: President, Colonel C. S. Gzowski; Vice-Presidents, John Kennedy and E. T. Hannaford; Treasurer, H. Wallis; Secretary, H. T. Bovey; Librarian, C. Chadwick.

Boston Society of Civil Engineers.—At the regular meeting in Boston, January 15, Louis M. Bancroft and George M. Fernald were elected members. The new Constitution and By-laws reported at a former meeting were adopted. They contained provisions for a new class of members called Associates, to which persons who are not engineers by profession are eligible. It also provides for temporary membership of persons who are members of other engineering societies, but residing for a limited time in or near Boston.

The Secretary and Treasurer were appointed a Committee to arrange for the annual dinner on March 12. It was resolved to employ a stenographer to report the discussions at the meetings.

Professor Thomas M. Drown read a paper on the Filtration of Natural Waters, which was discussed by Dr. Samuel W. Abbott, of the State Board of Health, and by Messrs. FitzGerald, Smith, and Watson, members of the Society.

New England Railroad Club.—At the regular meeting in Boston, February 12, the subject for discussion was the form of Contract for Chilled Wheels adopted by the Master Car-Builders' Association. It was opened by Mr. J. N. Lauder, who read a paper by Mr. W. W. Snow. The discussion was carried on by Messrs. Marden, Shinn, Curtis, Adams, and Nye, and developed great difference of opinion, the wheel-makers claiming that the contract did not do them justice.

Engineers' Club of Philadelphia.—At the regular meeting, January 18, the Secretary presented for Mr. Charles S. Churchill an illustrated paper on an Economical Form and Construction of Arches in Railroad Embankments. The paper was based on investigations made and plans and facts collected some time ago, when the Author made a number of experiments on the pressure of earth to be resisted by such arches both of small or larger spans. There was considerable discussion of this paper and on arches in general.

Engineers' Society of Western Pennsylvania.—At the regular meeting in Pittsburgh, December 17, C. I. McDonald and J. R. Reed were chosen members.

Mr. Alfred E. Hunt read an elaborate paper on Stone Used for Structural Purposes in Alleghany County, giving the results obtained with a number of different stones, the sources from which they were brought, and other particulars. This was discussed by Messrs. Becker, Hoag, Schneider, Scaife, and Brashear, many interesting facts being brought out in the discussion.

Central Railroad Club.—The annual meeting was held in Buffalo, N. Y., January 22, with a large attendance. Five new members were elected. Reports were presented on Seam-checks in Car-wheels and on Evaporation in Locomotives Burning Bituminous Coal. Both of these reports were discussed.

The Committee on the Interchange Rules presented a report recommending several changes. This was discussed for some time, and the Committee was continued with the addition of four members to its number.

Officers were elected for the ensuing year as follows: President, Eugene Chamberlain; Vice-President, A. C. Robinson; Secretary and Treasurer, F. B. Griffith; Executive Committee, T. A. Bissell, J. D. McIlwain, P. H. Griffin, C. A. Gould, Peter Smith, James Macbeth and C. E. Rood.

After the conclusion of the meeting the annual dinner was held, at which there were present 80 members and invited guests, and which was much enjoyed by those present.

Engineering Association of the Southwest.—At the regular meeting in Nashville, Tenn., January 9, communications were received from the Association of Engineering Societies relative to the subject of the formation of a national organization of engineering societies, and from President MacLeod, of Louisville, Ky., donating a pair of large photographs of the recently constructed Kentucky and Indiana bridge over the Ohio River at Louisville. The photographs were taken in April, 1886, during a 55-ft. rise of the Ohio River, and showed the cantilever trusses in process of erection, and presented ocular proof of the superiority of the cantilever type of bridge in the important particular among others of requiring for erection no false-work that might be endangered by unexpected floods in the river, which caused one of the long spans of the Chesapeake & Ohio bridge at Cincinnati to fall while resting on the false-work during the summer of 1888. The photographs are the first of a collection of maps, drawings, photographs, plates, models, and specimens which it is one of the expressed objects of the Association to gather and preserve in its permanent quarters.

Reports were read from the standing Committee on Rooms and Library relative to the furnishing of the recently selected quarters in Baxter Court, and from the standing Committee on Papers and Printing, relative to the system of receiving and presenting papers at the regular meetings. Suitable papers, discussions of papers, notes of professional experience, and items or accounts of technical interest are solicited from the membership, and such matter on any subject will be received

and presented at any time, though it is requested that, as far as is practicable, such matter shall be submitted in conformity with a prearranged schedule of general topics, by which each regular meeting for several months in advance shall have assigned to it a particular though comprehensive topic, under which all papers or communications on any particular subject closely allied to the general topic shall be admitted.

The constitution of the Association provides that one of the means by which its objects are to be obtained may be the taking of organized action on matters pertaining to engineering and allied professions. Acting under this provision the following resolutions, bearing on the subject of highway reform, were introduced:

"*Whereas*, The subject of efficient highways is one of the highest importance to the social and material welfare of the public; and

"*Whereas*, The questions involved in the bringing of highway systems to a high state of efficiency are largely questions falling within the province of engineers to consider; therefore, be it

"*Resolved*, That this Association express its appreciation of the desirability and the urgent necessity for strong and effective measures on the part of county and State legislatures looking to the improvement of public highway systems.

"*Resolved*, That a special committee of five members of this Association be appointed by the President, whose duty it shall be to consider and report at an early meeting what steps, in its opinion, the Association may properly take in order most effectively to aid in the general work of highway improvement."

The resolutions were referred to the Board of Directors for submission to the membership by letter-ballot.

The paper of the evening on a Chemical Examination of the Water Supply of Natchez, Miss., was then read by Dr. William L. Dudley, of Vanderbilt University. The paper comprised primarily a comparison of chemical analyses of water submitted from two possible sources of supply for the city of Natchez, namely, the Mississippi River opposite that city, and deep bored wells sunk between the Natchez bluffs and the river; though, as treated by the Author, the paper was given a much wider scope by his clear and concise presentation of the relation which a chemical analysis bears to a proper knowledge of the potability of a water supply; a question of great importance to sanitary engineers. The analysis showed the superiority of the well-water over the river water in having less solids in suspension, less organic matter, in solution, less albuminoid ammonia, and a lesser degree of permanent hardness; but inferiority to the river water in having nearly three times as high a degree of temporary hardness, and a small excess of total hardness.

The Association will begin at an early date the publication and distribution among its membership of the more valuable papers read at the meetings.

Engineers' Club of Cincinnati.—At the regular meeting, January 16, Alfred Bull and A. S. Hobby, Jr., were chosen members Mr. L. W. Mathewson read a very interesting paper on Street Construction, which included a description of the construction of various kinds of street pavements and of the material used in them. This paper was followed by an interesting discussion in which Messrs. Merrill, Hobby, Carlisle, Hilgard, Burke, Nicholson and Wallace took part.

Western Society of Engineers.—At the regular meeting in Chicago, February 5, President Cooley made an address outlining the policy of the Society for the ensuing year.

Mr. O. Chanute gave an account of the Paris Exposition as seen by him, and showed what was to be done in preparing for the Exposition of 1892, in the light of the experience had in Paris.

Western Railway Club.—At the regular meeting in Chicago, February 18, a paper on Steel Plate and Malleable Iron in Car Construction was read by Mr. E. W. M. Hughes, and discussed.

There were short discussions on Valve Motions and on Car Roofs. The Rules of Interchange of the Car-Builders' Association were also suggested for discussion.

Northwestern Track & Bridge Association.—At the regular meeting in St. Paul, February 15, there was a discussion of the paper on Track Shimming read by Mr. Kimball at the previous meeting.

Mr. John Copeland read a paper on Care of Pile Bridges in Winter, which was briefly discussed.

This Association has been organized at St. Paul, Minn., with the following officers: President, John McMillan; Vice-Presidents, W. S. Darby and George W. Kimball; Secretary, D. W. Meeker; Treasurer, John Copeland.

At the first regular meeting a paper on Track Shimming was read by Mr. G. W. Kimball. Discussion was postponed till the next meeting.

Northwest Railroad Club.—At the regular February meeting Mr. W. H. Lewis read a paper on Axles for Heavy Tenders, in which he recommended the use of an axle with journals 4 in. diameter and 8 in. long, the axle to be not less than 5⅝ in. diameter at the wheel-seat and 4⅝ in. at the center. This was discussed by Messrs. McIntosh, Greatsinger, Whitaker, Pattee, and Warren, most of them favoring a smaller journal.

Engineers' Club of St. Louis.—At the regular meeting January 22, B. J. Arnold and James Dun were chosen members. The Committee on the Eads Monument reported progress.

Professor W. B. Potter then read a paper on Fuel Gas, considering the subject under the heads of Natural and Manufactured Gas. He assumed the amount of natural gas now consumed is equivalent to about 15,000,000 tons of coal yearly. He believed that under present conditions manufactured fuel gas could not be profitably used in steam boilers, but believed that the cost of manufacture and the price of manufactured gas would be so reduced that it could be largely used for domestic purposes.

Mr. E. McMillin made an address on the same subject, agreeing generally with Professor Potter's statements. The subject was further discussed by a number of members present.

At the regular meeting, February 5, J. L. Ayers, C. W. Counet, B. L. Crosby, J. H. Curtis, G. H. French and A. Winslow were chosen members.

Mr. George D. Dudley read a paper on Tests of Water Works Engines, explaining the precautions necessary to be taken in making such tests in order to secure results of value. He also submitted reports on two tests of engines. This was discussed at considerable length by a number of the members present.

The Secretary then read a paper by Mr. J. H. Kinneally, entitled Some Mathematics on Ventilation. This was also discussed by members present.

Engineers' Club of Kansas City.—At the regular meeting held January 6, the reports of the Executive Committee and the Treasurer were presented. Messrs. O. B. Gunn and W. B. Knight were appointed to serve on the Committee on National Public Works and Messrs. Kiersted and Henry Goldmark on the Committee on Affiliation of Engineering Societies.

The tellers announced the election of the following officers for the ensuing year: President, W. H. Breithaupt; Vice-Presidents, J. A. L. Waddell and A. J. Mason; Secretary, Kenneth Allen; Treasurer, F. W. Tuttle; Librarian, C. E. Taylor; Directors, W. B. Knight and W. Kiersted.

The retiring President, Mr. O. B. Gunn, then delivered an address referring to the prosperous condition of the Club, the work done by various members and several of the great engineering enterprises now being carried out.

Denver Society of Civil Engineers & Architects.—At the regular meeting in Denver, Col., January 28th, the following officers were elected for the ensuing year: President, George G. Anderson; Vice-Presidents, L. Aulls and C. P. Martin; Secretary and Treasurer, George H. Angell; Executive Committee, P. H. Van Diest, R. D. Hobart and F. E. Edbrooke.

A Committee was appointed to consider all matters appertaining to a national association and to union with other Societies. Messrs. C. P. Allen, William H. Weller and Ernest Van Dreveldt were elected members.

Mr. R. A. Wilson then read a paper upon the Necessity of Good Triangulation Surveys, speaking also of the importance of good topographical maps of the State.

Montana Society of Civil Engineers.—The annual meeting was held in Helena, Mont., January 18. The Secretary reported that there were now 56 active and two associate members. The Treasurer reported expenditures amounting to $287 and a balance of $184 on hand. Mr. Sizer was appointed to fill a vacancy in the Committee on National Public Works.

The election of officers for the ensuing year was announced as follows: President, Eldridge H. Beckler; Vice-Presidents, John Gillie and John Herron; Secretary and Librarian, Charles E. Griffith; Treasurer, Albert S. Hovey; Trustee, A. E. Cumming. The new President made a short address and votes of thanks were passed to the retiring officers.

Technical Society of the Pacific Coast.—At the annual meeting in San Francisco, January 24, the following officers were elected: President, John Richards; Vice-President, Professor F. Soule; Treasurer, James Spiers; Secretary, Otto von Geldern; Directors, Ross E. Browne, L. L. Robinson, Herman Kower, S. H. Smith and Hubert Visscher.

Tacoma Society of Civil Engineers and Architects.—At the regular meeting in Tacoma, Wash., December 20, a discussion took place on Piles, in which the many experiments made by the Northern Pacific in the Puget Sound country were given by its Engineer, H. S. Huson, and discussed by members present. In that country the destruction of piles by boring animals is very rapid, and timber being very cheap, it has heretofore been less costly to renew them than to protect them. Attention has been called to the use of concrete and of Ventura asphalt.

A paper was read by S. A. Cook on Construction of Buildings, and another one on the same subject by James Morrison. Both referred to the necessity of better building and better sanitary arrangements.

At the annual meeting, January 17, the following officers were elected: President, D. D. Clarke; Vice-President, Arthur L. Smith; Secretary, William G. Gosslin; Treasurer and Librarian, F. G. Blake. The officers reported the Society in a flourishing condition, and that suitable rooms had been procured.

William J. Wood read a paper upon the Coal Deposits of the State of Washington, their nature and probable area, which was of much interest.

C. O. Bean read a paper upon Street Improvements, which was generally discussed, and which condemned wooden pavements, which are largely used at present in that country of cheap timber.

Connecticut Association of Civil Engineers & Surveyors.—At the annual meeting in Hartford, January 14, the Secretary's report showed a membership of 80, and several new members were admitted. President C. H. Bunce made a carefully-prepared address, showing what engineering work had been done in the State during the year, and calling attention to the necessity of having town lines fixed and marked. Messrs. Weld, Whitlock, and Hull were appointed a committee to attend the next annual State convention of selectmen and urge action in regard to the boundaries.

In the afternoon A. R. Wadsworth, of Farmington, read a paper on the Farmington Water-Works, and F. Floyd Weld, of Waterbury, read an article entitled Notes on the Care of Sewers. W. E. Petter, of Lakeville, spoke of the methods of heating passenger cars. The Committees on Railroads, Sewers, Masonry, Roads and Road-Making, and Water-Works made reports.

Officers were elected as follows: President, F. Floyd Weld, of Waterbury; Vice-Presidents, William B. Palmer, of Bridgeport, and E. P. Augur, of Middletown; Secretary and Treasurer, F. W. Whitlock, of Waterbury; Assistant Secretary, W. H. Burnett, of Norwich; Executive Committee, F. F. Weld, C. H. Bunce, C. M. Jarvis, C. E. Chanler, and B. H. Hull; Membership Committee, T. H. McKinney, E. P. Augur, and W. B. Palmer.

Ohio Society of Surveyors & Engineers.—At the annual meeting in Columbus, O., January 21–23, among the papers read were the following: The Motor in Engineering, by B. F. Thomas; County Surveyors, by William Peters; Sewage Disposal, by Doctor Edward Orton; Town and Village Water Works, by G. B. Strawn; Rural Water Supply, by J. Arenett; Natural Gas, by H. L. Webber. There were also papers read and discussed on Street Construction, on Highways and on Railroad Permanent Way.

Officers were elected as follows: President, J. F. Buck, Cardington; Vice-President, G. R. C. Brown, Ironton; Secretary and Treasurer, Julian Griggs, Columbus.

Indiana Society of Civil Engineers & Surveyors.—At the annual meeting in Indianapolis in January, the usual business was transacted, and the following officers were elected: President, P. I. Morris, Knightstown; Vice-President, L. S. Alter, Remington; Recording Secretary, J. R. Brown, Frankfort; Corresponding Secretary, G. M. Cheney, Logansport; Treasurer, H. P. Faitout, Indianapolis; Executive Committee, Jacob Norris, W. A. Osmer, R. H. Wallace, R. J. Morrison and G. M. Cheney.

Illinois Society of Engineers & Surveyors.—The fifth annual meeting was held in Peoria, Ill., January 29, continuing for three days. The meeting included several excursions to the water-works and manufacturing establishments in and near Peoria and over the electric railroad. A large number of drawings and photographs of structures and machinery were exhibited by members.

The following officers were elected for the ensuing year: President, A. N. Talbot, Champaign; Executive Secretary and Treasurer, S. A. Bullard, Springfield; Recording Secretary, S. F. Balcom, Champaign.

Among the papers presented were the following: Sharp Curves, by Edwin H. Hill; The Use of Mortar, by Professor I. O. Baker; The Cairo Bridge, by S. F. Balcom; Washington Street Tunnel, Chicago, by S. C. Colton; Iron Highway Bridges, by J. H. Burnham; Peoria Water Works, by W. C. Hawley; Preventing Abrasion of River-Banks, by E. J. Chamberlain; The Engineer and his Work, by C. G. Elliott. There were also discussions on Repairs of Pile Bridges, Ties and State Jurisdiction as to railroad accident.

Michigan Engineering Society.—The Eleventh Annual Convention of this Society was held in Detroit, Mich., beginning on Tuesday, January 21. The programme for the meeting was as follows:

January 21: Papers on Engineering, by H. C. Thompson; Long and Short Haul in Earth Work, by O. C. Gillette; The Mexican Boundary Survey, by J. H. Forster; The Northern Boundary Survey, by Professor C. E. Denison.

January 22: Papers on the Plane Table, by Professor H. B. Davis; Bridge Inspection, B. Douglass; the St. Clair Tunnel, A. L. Reed; Photographic Surveying, Professor R. C. Carpenter; Harbor Point Resort, George E. Steele; Surveying in Oklahoma, O. H. Todd. The evening was devoted to a social meeting and reception.

January 23: Papers on Irrigation, by Professor L. G. Carpenter; Drainage of the Huron Peninsula, F. F. Rogers; Laws on Drainage, Willis Baldwin; Means Employed in Running a Straight Line, George L. Wells; Paper, Professor M. E. Cooley; Ypsilanti Water-Supply, W. R. Coats.

The business session for election of officers, etc., was held January 23. In addition to the reading of papers, opportunity was given at several sessions for miscellaneous debate, asking of questions, etc.

NOTES AND NEWS.

An Air Ship.—The following will thrill the soul of every boy who reads it: "A kite 16½ ft. high and 12 ft. wide, made of 54 yards of linen, was recently made by five boys in Terryville, Conn. At its first ascent it went up 2,000 ft."

A Great Freight Yard.—The Baltimore & Ohio's new yard at Berlin, Md., will be about two miles long by about 500 ft. wide. The main tracks will spread at either end and bind upon each side of the yard. The main sidings, one on each side of the yard, will be immediately inside of and parallel with the main passing tracks. Inside of and parallel with the main sidings are the bases of the diagonal, from and between which are laid the diagonal tracks running at an angle of about 30°. Of these diagonals there are to be 70, each with a capacity of 45 cars, on the basis of 37 ft. space for each car, measuring from bumper to bumper. This gives the yard an aggregate capacity inside of the base of 3,150 cars. Each diagonal will connect with the base on either side by easy switches. The bases will connect with the main sidings at intervals of 10 diagonals, but such connections may be increased to any number desired. The main tracks will have only two connections with the yard, one at each end, so that passenger trains may not suffer the slightest delay. The diagonal tracks are to be numbered from 1 to 70.

Each diagonal will be reserved for its own particular train. For instance. Nos. 1, 2, 3, and 4 may contain all cars intended for Locust Point, and none other; Nos. 5 and 6 only those for Camden Station; Nos. 7, 8, and 9 for Philadelphia, 10 and 11 for New York, 12 and 13 for the Valley, 14 for the Hagerstown

Branch, 15 and 16 for Washington, 17, 18, 19, and 20 for Pittsburgh Division, 21 to 30 for the Baltimore & Ohio Southwestern, etc. So that in ordering out an engine and crew for a Locust Point run, say, the yardmaster simply directs: "Find your train of 25 cars (or 30 or 45 cars, as the case may be) on No. 2." By the peculiar construction of this yard there is no danger, it is claimed, of blocking it. Thirty to 40 switching engines can work in the yard at the same time without interfering with one another. Incoming freight trains will pull into the main siding from the main track at the end of the yard, and from the main siding to the base, where it is left to the switch engine, the main-line locomotive and crew proceeding to the round-house.

The round-houses, warehouses, etc., are to be at the west end of the yard. The entire yard will at night be bright as day with the use of arc electric lights.

It is probable that the officials will in the near future increase the length of freight trains to 45 cars. Twenty-eight is the usual number hauled by one locomotive at present.—*Baltimore Sun.*

A Great Light-House.—The Light-House Board expects to open bids next July for the erection of a light-house on the Outer Diamond Shoal off Cape Hatteras, which will be one of the notable light-houses in the world, on account of the difficulties in the way of its construction which have hitherto prevented the erection of any light-house there. The Light-House Board does not specify the method to be adopted by the builders, but it is generally understood that the design is for an immense caisson, 80 or 100 ft. in diameter, which will be towed out to the shoal and sunk in place as rapidly as possible. The sand will be excavated from the caisson and it will be sunk until its edges rest upon the bed-rock, when it will be filled with concrete to a height some 30 ft. above high water, and a light-house tower which will be 150 ft. in height will be founded upon this mass. The caisson will be protected outside by a riprap of heavy granite blocks. The tower itself will be of steel. The placing of the caisson and the construction of the foundation will be exceedingly difficult on account of the constant interruptions which may be expected from rough weather, as the sea off Cape Hatteras is seldom long at rest.

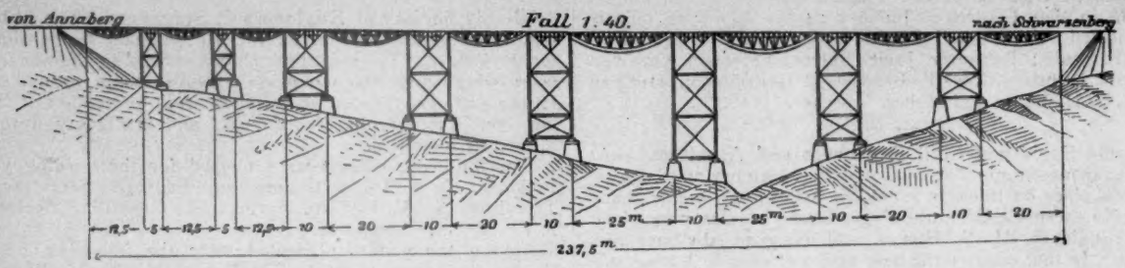
Young Men's Christian Association.—We learn from the *Rocky Mountain Messenger*, published by the Railroad Department of the Young Men's Christian Association on the Union Pacific Railroad, that that organization now has rooms on the line of the road at Rawlins, Wyo.; Pocatello, Ida., and Ogden, Utah, the work at each place being in charge of a local secretary. At each of these points the rooms, which are provided with baths, library and other conveniences, are very attractive, and the aggregate membership is now over 500 and is rapidly increasing. The rooms are very largely used by trainmen and other railroad men, and the work of holding meetings, distributing papers, visiting the sick, etc., is carefully attended to. Social receptions are also held, and lectures given from time to time.

An additional branch is to be established at Green River as soon as rooms can be obtained there.

Testing the Forth Bridge.—The preliminary test of the Forth Bridge was made January 21. The two 1,700-ft. spans were tested by placing on the centers two trains, each made up of 50 loaded coal cars and three of the heaviest engines, the total load thus massed being about 1,800 tons, or more than double that which will be thrown upon the bridge in practice. The observed deflections were in accordance with the calculations with the engineers, and the bridge exhibited exceptional stiffness in all directions. It is also stated that during a heavy gale a few days before, when the wind gauges indicated a pressure of 37 lbs. per square foot, the maximum lateral movement of the great cantilever was less than one inch.

The first passenger train crossed the bridge January 24, carrying the engineers and a number of officers of the Great Northern & North British Companies. The train crossed at a speed of 12 miles an hour, and returned at about 15 miles an hour. The formal opening of the bridge is to take place March 4.

The Mittweida Viaduct.—The accompanying illustration shows a viaduct recently built over the Mittweida Valley on the Annaberg-Weiperter line of the Saxon State Railroad in Germany. As shown by the cut, it is a truss-bridge supported on



iron piers, and the German technical papers note it as a step toward the adoption of American methods of bridge construction. It was built under contract by the Königin-Marienhütte Company, at Cainsdorf, near Zwickau.

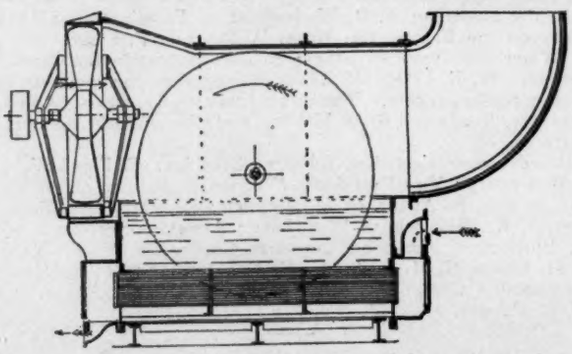
The total length of the viaduct is 237.5 meters (779 ft.). There are three spans of 12.5 m (41 ft.) each; four of 20 m. (65.6 ft.) each, and two of 25 m. (82 ft.) each. There are also eight short spans over the piers, two of them of 5 m. (16.4 ft.) each, and six of 10 m. (32.8 ft.) each.

The height of the piers varies, there being two of 12 m. (39 4 ft.); two of 15 m. (49.2 ft.); one of 20 m. (65.6 ft.); two of 25 m. (82 ft.), and one of 30 m. (98.4 ft.).

The total weight of the ironwork in the viaduct is 578 tons. It was erected in eight weeks by the contractors, in spite of very unfavorable weather, having been completed on December 1 of last year. It may be added that the viaduct is on a grade of 132 ft. to the mile.

A Railroad Monument.—The Pennsylvania Railroad Company is now placing a monument alongside the line of its Amboy Division, near Bordentown, to mark the location of the first mile of railroad laid in New Jersey, which was a section of the old Camden & Amboy Railroad, which, when first built, ran from Bordentown to South Amboy, and was for a time operated by horse-power. Some of the original spikes and flat plates used in the construction of the road have been preserved and will form a portion of the monument.

A New Condenser.—The accompanying illustration shows a novel form of condenser which has been used with considerable success in Germany and other parts of the Continent. The exhaust steam from the engine enters at the right of the engraving, and passes through a series of brass pipes immersed in



water, to which it gives up its heat. Between each section of tubes a number of galvanized disks are caused to rotate. These disks are cooled by a current of air supplied by the fan shown at the left of the illustration, and pass down into the water, cooling it by abstracting the heat given out by the exhaust steam and carrying it up where it is driven off by the air current. The disks serve also to agitate the water and thus aid it in abstracting the heat from the steam. With 85 per cent. vacuum the temperature of the cooling water was about 130° F., and a consumption of water for condensing is guaranteed to be less than a pound for each pound of steam condensed. For an engine 40 in. × 50 in., 70 revolutions per minute, 90 lbs. pressure, there is about 1,150 sq. ft. of condensing surface. Another condenser, 1,600 sq. ft. of condensing surface, is used for three engines 32 in. × 48 in., 27 in. × 40 in., and 30 in. × 40 in. respectively.—*The Steamship.*